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BLOOD AND LYMPH VESSEL TUMORS

A Report of 1,056 Cases

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An angioma, as defined by Ewing, is a true neoplastic process involving vascular or lymphatic tissue. In this respect an angioma differs distinctly from simple, self-limiting vessel hypertrophy such as occurs in granulation tissue, and it bears no relation to the ordinary dilatation of previously formed vessels such as occurs in varices. It is generally believed that simple angiomas are congenital in nature and have their origin in embryonic sequestrations of mesodermal tissue, and also it seems well established that the three types of benign blood and lymph vessel tumor (hemangioma, lymphangioma, and hygroma) not only have a common origin, but grow in an identical fashion by projecting buds of endothelial tissue (Ribbert and Goetsch). The present study brings out an additional fact of certain similarities in the response of these growths to the various therapeutic agents.

Since blood and lymph vessel tumors have a common origin, develop and grow in identical fashion, and show certain common features in response to treatment, it seems logical and desirable to us that they be studied in detail as a group. In this report it has been our purpose to classify these tumors, and, in so far as possible, describe and correlate their known therapeutic responses with their clinical and pathological characteristics. Another aim has been to evaluate the different treatment measures and point out certain pitfalls and hazards to be avoided in the management of these tumors. The present report is a study of the patients with benign blood and lymph vessel tumors admitted to Memorial Hospital during the years 1931 to 1939. A group of 1,056 patients with a total of 1,363 lesions (Table I) is suitable for statistical study.

From the Memorial Hospital.

HEMANGIOMA

This type of blood vessel tumor inherits from its embryonic parent a certain power of irregular and unrestrained growth. The average hemangioma pursues a benign course and, if untreated, grows slowly up to adult life. All hemangiomas, however, do not follow this general rule. Occasionally one will suddenly develop rapid acceleration of growth, become locally destructive, and may even cause death by hemorrhage or sepsis if not treated promptly. In all but the racemose type, tumor growth generally stops with full body growth.

Hemangiomas enlarge and develop by extending solid "buds" of endothelium into

TABLE I.—BLOOD AND LYMPH VESSEL TUMORS —SUMMARY—IN 1,056 PATIENTS STUDIED

Hemangioma	
Cavernous	952
Capillary	291
Bone	5
Muscle	10
Special Organs	4
Racemose type	9
Diffuse systemic type	9
Port wine stains	19
Rendu-Osler-Weber disease	9
	1,308
Lymphangioma	41
Hygroma	14
Total individual lesions of all types	*1,363

adjacent tissues. These solid cords of endothelial tissue then become canalized and establish communication with the parent vessel. They do not, however, invade or communicate with surrounding normal vessels. The histological studies carried out in preparing this report tend to confirm Ribbert's original theory that a hemangioma, with the exception of the racemose type, has no anastomotic connection with surrounding vessels and possesses only one afferent and one efferent vessel. The occasional spontaneous regression of a hemangioma results from the accidental, thrombotic occlusion of this very tenuous blood supply.

The hemangioma material available for this report consists of 1,001 patients presenting a total of 1,308 lesions. Multiple lesions were noted in 16 per cent of the patients. The cases included in this series represent 5 per cent of all the admissions to the Memorial Hospital during the 8 year period under consideration.

Strongly supporting the theory that hemangiomas are of congenital origin is the fact that 73 per cent of the patients presented evidence of tumor at birth. More than 85 per cent of the lesions had developed before the end of the first year, and undoubtedly many of these were present at birth but were unnoticed because of their minute size. There is also reason to believe that many of the hemangiomas which allegedly did not appear until adult life were present earlier but were not noticed until they suddenly began to enlarge.

TABLE II.—BLOOD AND LYMPH VESSEL TUMORS —HEMANGIOMA, ITS RELATION OF PATIENT'S AGE TO RADIOSENSITIVITY OF TUMOR

Age	Total cases	Percentage good regression	
		Cases	Percent
0 to 3 months	20	20	100
4 to 6 months	37	34	92
7 to 9 months	19	15	79
10 to 12 months	21	18	85
1 to 10 years	22	18	81
Over 10 years	1	0	0
Total	120		

Primary regression of 120 cases of hemangioma treated with *single* dose of radon radiation in a brass plaque container.
Conclusion: The radiosensitivity of angioma varies inversely with the age of the patient.

Hemangiomas make up the largest single group of neoplasms occurring in childhood. Females are more frequently affected than males, the ratio in this series being 65 per cent to 35 per cent. The relative frequency of this lesion in females as compared with males is a consistent feature in the world literature of this growth, and in some clinics the proportion runs as high as 3 to 1. Although no acceptable explanation for this higher female incidence has ever been offered, it is suggested that hemangiomas may in some fashion be related to the female sex hormones, and in this connection it is of interest to note that a hemangioma may start or increase rapidly in size with the onset of the menses or at the beginning of pregnancy. Only one negro boy was treated, and this low incidence (0.1 per cent) suggests that hemangiomas are relatively rare lesions in the negro race.

The head and neck regions make up less than one-seventh of the total body surface, but more than one-half (56 per cent) of all hemangiomas in this series occurred in those locations. The anatomical distribution of all the lesions in this series was: head, 52 per cent; neck, 4 per cent; trunk, 23 per cent; extremities, 19 per cent; and genitalia, 2 per cent.

CLASSIFICATION

A rigid and inclusive classification of hemangiomas would be difficult and yet to eliminate confusion one must be somewhat arbitrary. We feel that a satisfactory classification should attempt to group the lesions according to their clinical and pathological characteristics in so far as they tend to serve

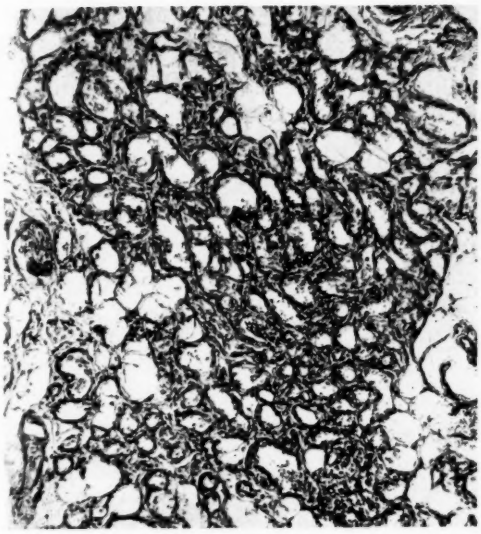


Fig. 1. A.P. Capillary hemangioma. The capillary vessels are lined with a single layer of well differentiated endothelium. The stroma is scanty. ×65.

the dictates of the various methods of therapy. The following simplified classification of hemangiomas is proposed primarily because it includes the therapeutic point of view and is based strictly on comparative clinical, pathological, and therapeutic considerations: (1) capillary hemangioma, (2) cavernous hemangioma, (3) angioblastic or hypertrophic hemangioma, (4) racemose hemangioma, (5) diffuse systemic hemangioma, (6) metastasizing hemangioma, (7) nevus vinosus or port-wine stain, (8) hereditary hemorrhagic telangiectasis (Rendu-Osler-Weber disease).

1. The capillary form of hemangioma consists of a new-growth of capillary blood vessels with well differentiated endothelium and delicate connective tissue stroma. The capillary vessels are lined with a single layer of endothelial cells and their lumens usually contain only a few blood cells. As a rule, this type clinically appears as a well circumscribed, finely lobulated, slightly elevated tumor, bright red in color (Figs. 1, 2, 3). These growths are usually situated superficially in the skin and range from a few millimeters to several centimeters in diameter. The rapidly growing lesions may attain a thickness of 1 to 2 centimeters and simulate the cavernous type. Because of its narrow vessel lumen, the capillary hemangioma blanches poorly under pressure and is not as compressible as a cavernous hemangioma.

Fig. 2, left. Ten month old girl with a slightly raised, bright red, capillary hemangioma measuring 3 centimeters in diameter, which blanched poorly on pressure.

Fig. 3. Same hand 8 months later following 8 applications of solid carbon dioxide snow.

Closely associated with the capillary type are the mixed forms such as angiolipoma, angiofibroma and the stellate or "spider-web" hemangioma. The stellate hemangioma, so called because of its large central capillary and fine stellate vessels, usually occurs in adults and rarely exceeds 4 or 5 millimeters in diameter.

2. The cavernous hemangioma is composed of thin walled, endothelium-lined, widely dilated blood sinuses engorged with blood cells (Figs. 4, 5, 6). The lesions are soft, elevated, and generally poorly circumscribed. They are purplish blue in color, easily compressible, and blanch readily under pressure. The deeper type is more diffuse and assumes a darker bluish color.

Cavernous hemangiomas generally have a greater thickness than the capillary ones and extend deeper into the subcutaneous tissues. They are more extensive, tend to be aggressive, and may attain great size. In the neck there is the constant danger of this tumor developing arteriovenous connections and resulting in fatal hemorrhage. Mixed capillary-cavernous types are common, the capillary portions usually surmounting the cavernous lesion in the overlying skin.

The subforms of cavernous hemangioma comprise almost all the hemangiomas of spe-

Fig. 4. A.R. Cavernous hemangioma. The thin walled, endothelium lined, widely dilated blood sinuses are engorged with blood cells. These lesions are easily compressible and quite suitable for injection therapy. ×65.

cial organs, such as liver, intestine, bone, and muscle.

Cavernous hemangiomas of the liver are relatively common, but because of their asymptomatic nature are usually found only on postmortem examination. They may grow to a very large size and are invariably located near the liver surface.

Hemangioma of bone is clinically uncommon and occurs chiefly in the lumbar vertebræ (Figs. 7 and 8). Topfer routinely sectioned vertebræ in 2,154 postmortem examinations and found angiomas in 12 per cent of the cases. Few of these patients had shown any symptoms. In our series of 5 cases of bone angioma, 3 occurred in the bodies of the lumbar vertebræ, 1 in a mandible and 1 in a rib. In the vertebral series, the symptoms were characteristic of spinal cord compression. Roentgen findings in all 3 cases consisted of the typical "vertical striations" as noted by Bucy and Capp in their excellent review of this subject.

Hemangioma of striated muscle (Fig. 9) was noted in 10 cases, an incidence of 1 per cent, and all lesions but one developed before

Fig. 5, left. G.C. Aggressive cavernous hemangioma of cheek. Raised, purplish red, compressible lesion measuring 6 by 5 by 2 centimeters. It was noted at birth. Treatment consisted in radon plaque followed by insertion of gold filtered radon seeds.

Fig. 6. Result 4 years later. There is slight radiation fibrosis.

the age of 10. In 6 cases (60 per cent) the lesions were located in the extremities, chiefly the thigh. Six patients were females and 4 were males. Symptoms were strikingly similar in most instances and consisted of pain, functional impairment, and diffuse tumefaction which decreased with limb elevation. Aspiration of blood from the tumor and the detection of phlebolith shadows on roentgen examination assist in establishing a correct diagnosis.

3. The angioblastic or hypertrophic type of hemangioma occurs chiefly in the skin (Figs. 10, 11, 12). It appears as a solid, elevated, purplish red lesion which is not compressible. On section it consists of a solid mass of endothelial cells with a minimum of patent vessels. Vessel lumens have been obliterated as a result of the rapid proliferation of the embryonic endothelium. The pure type is often mistaken microscopically for a hemangiosarcoma and, as a matter of fact, is frequently found to be locally aggressive and is prone to recur after operation.

4. The racemose or cirsoid type of hemangioma, a relatively rare lesion, consists of a pulsating mass of dilated, thickened, tortuous arterioles and proliferating capillaries which have established communication with surrounding normal blood vessels. Clinically, it appears as a soft, bulky, bluish-red pulsating mass suggesting a writhing mass of earthworms. These destructive lesions appear chiefly in adults and are characterized by

Fig. 7. S.W. Cavernous hemangioma of rib. Large dilated sinuses filled with blood and destroying bone. The patient, a 22 year old female, complained of pain and slight tumefaction of the tenth rib of several months' duration. The rib was excised and there has been no recurrence. ×75.

Fig. 8. N.G. Hemangioma of the second lumbar vertebra. Note the characteristic vertical striations. The patient, a 33 year old female, complained of pain localized over the dorsal spine of 4 years' duration. The lesion was treated with divided doses of high voltage roentgen therapy for a total of 1500 r with relief of symptoms.

their sudden onset. They develop externally and are located almost solely about the face or neck. Not infrequently they appear to spring from previously quiescent port wine stains. On rare occasions they appear as a diffuse lesion involving an extremity. Once having established communication with a large blood vessel, such as the carotid artery, this tumor becomes locally destructive by reason of the constant arterial pulsations, and it may then erode the cranial vault or orbit, or bulge into the oral cavity and lead to fatal hemorrhage (Figs. 13, 14, 15).

Nine cases of the racemose type are included in this report and they comprise the largest series of these tumors to appear in the medical literature. Two patients were infants and the others adults. The sex incidence was nearly equal, and all the lesions occurred about the head and neck.

5. *Diffuse systemic hemangioma.* The term is applied to a small group of tumors characterized by a diffuse overgrowth of a locally invasive capillary or cavernous hemangioma (Figs. 16, 17). An entire extremity is usually affected and the growth often appears to be a mixed hemolymphangioma. Due to the abnormal blood supply, almost every one of the 9 cases in our series showed visible and palpable evidence of tissue hypertrophy. In 2 patients definite angiomatous lesions were also observed in internal organs. In 1 case the kidney was involved and in the other case the sigmoid was the site of the lesion. Hence, the usage of the term "systemic."

6. The so-called *metastasizing hemangioma* is characterized by metastases which are as benign microscopically as the primary lesion. Only 4 proved cases have appeared in the literature (Robinson and Castleman). In 2 of them the primary lesion occurred in the breast. All 4 patients had visceral or pulmonary metastases. Recently, a similar case affecting the forearm was reported (Ward and Jones).

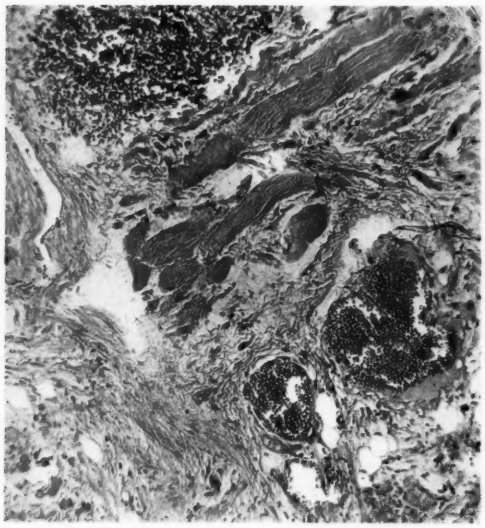


Fig. 9. J.M. Cavernous hemangioma of muscle. Note the dilated, cavernous sinuses circumscribing and destroying muscle bundles. The patient was a 14 year old female with a painful, diffuse swelling of the forearm which measured 7 by 4 by 2 centimeters and had been growing for 5 years. The lesion was successfully excised and no recurrence has been reported following operation. ×65.

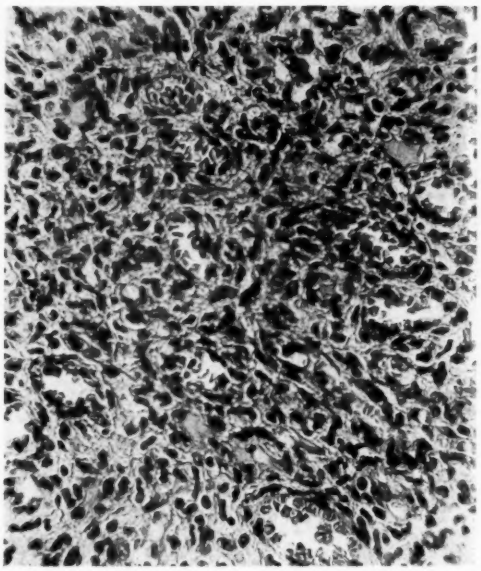


Fig. 10. B.K. Hypertrophic type of hemangioma. Note the marked proliferation of endothelial cells obliterating the vessels and forming sheets of rather solid tissue. Such features often lead to an erroneous diagnosis of sarcoma. This lesion was soft, faintly bluish, elevated, and measured 4 by 2 by 2 centimeters. It was not compressible and did not blanch with pressure. The patient was an 8 month old female. The lesion in the skin of the shoulder was not noted at birth and grew rapidly. ×190.

Fig. 11, left. L.H. Hypertrophic type of hemangioma. Raised, irregular, rather firm, light bluish hemangioma which blanched poorly on pressure. It measured 14 centimeters in its greatest diameter and was 5 centimeters in thickness. The patient was a 2 year old female. The lesion had been present since birth, and there was gradual growth. The lesion was removed by repeated partial excisions. No recurrence.

Fig. 12. Photograph of patient, showing cosmetic result 5 years after operation.

7. Nevus vinosus or port wine stain is a diffuse telangiectasia of superficial vessels of the derma. On section, a very narrow, superficial zone of scattered dilated vessels lined with flattened adult endothelium is seen (Figs. 18, 19). The proliferative mass characteristic of a real hemangioma is lacking. Clinically, the lesion presents a flat, irregular, bright purple patch in the derma which blanches on pressure. In all our 19 cases, the growth was noted at birth and showed no tendency to grow. Twelve patients (70 per cent) were males, a peculiar reversal of sex incidence when considered with hemangiomas as a group. In 88 per cent, the lesions were located on the face or neck.

8. Hereditary hemorrhagic telangiectasia or Rendu-Osler-Weber disease. Three classical requisites are necessary to establish this diagnosis. First, a history of repeated hemorrhages (usually profuse epistaxis); second, telan-

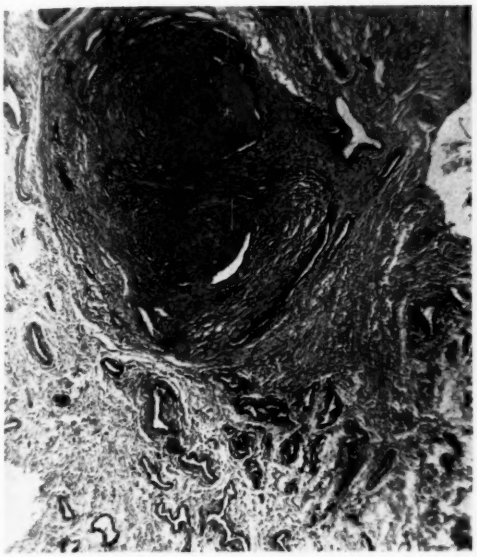


Fig. 13. N.C. Racemose type of hemangioma. Note the thickened arteriole showing considerable cellular proliferation in its walls. The smaller surrounding, thin walled vessels communicate directly with such an arteriole resulting in a cirsoid, pulsating mass. Clinically, the lesion appeared as a very early, soft, pulsating, bluish mass 3 centimeters in diameter and 1½ centimeters in thickness in the skin of the upper lid of a 16 year old girl. It was successfully treated by vessel ligation and sodium morrhuate injections.

giectatic lesions in the mucous membranes of the nasal or oral cavities, viscera, and occasionally in the skin; and third, familial occurrence. Eighty-five families afflicted with this disease have been reported and it is this hereditary feature which distinguishes it from multiple hemangiomatosis (O'Kane).

The telangiectatic areas appear as tiny, reddish-purple spots 1 to 3 millimeters in diameter (Figs. 20, 21). On microscopic examination they consist of extremely thin, dilated venules and capillaries lined with a delicate layer of endothelial cells. Unlike hemophilia, the disease is transmitted by both sexes, and the bleeding and clotting times are normal. The disease may manifest itself at any age, but the onset is most common during the fourth or fifth decades of life. Hemorrhage, which may be persistent and alarming, is fatal in only 4 per cent of the cases. One of our patients died as a result of gastric hemorrhage.

Fig. 14, left. G.V. Racemose type of hemangioma. A soft, bluish, cavernous, pulsating, compressible mass involving the entire left face and bulging into the oral cavity. The patient is a 60 year old male. The onset of the condition was at the age of 20.

Fig. 15. The lesion was surgically ligated and injected with sodium morrhuate on many occasions with satisfactory control.

Fig. 16, left. E.B. Diffuse systemic hemangioma of entire left leg. The left leg is slightly longer and slightly larger than the right and is faint bluish and of spongy consistency. The patient is a 14 year old girl. The condition was noted at birth and has progressed very slowly. Patient had a right nephrectomy recently for perithelial angioma of kidney.

Fig. 17. Infra red photograph. Note the superficial blood vessels in left leg.

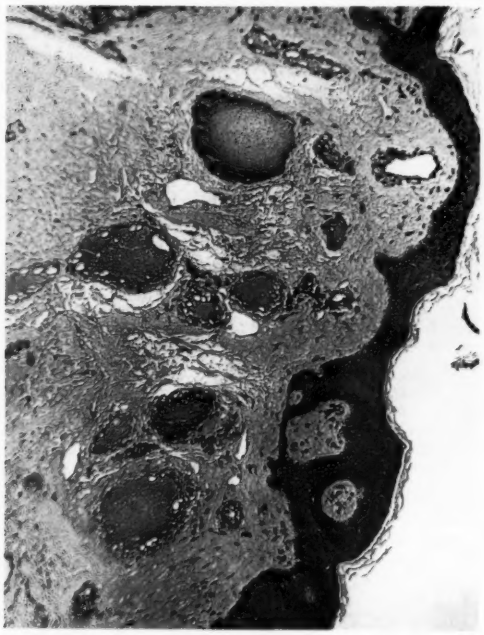


Fig. 18. W.S. Nevus venosus or port wine stain of face. Note the thin walled, scattered, superficial, telangiectatic vessels with thin adult endothelium. ×75.

Fig. 19. G.W. Nevus venosus or port wine stain of face. Eight month old male infant. The lesion was present at birth. No growth. It is characteristically bright purplish red, flat, and blanches poorly with pressure. It ends abruptly at the midline.

Death usually results from intercurrent infections which these anemic individuals cannot combat.

In this series of 9 cases there was no sex predilection, but there was a majority of Polish Jews. In all cases the nasal or oral mucosa was involved and several had definite telangiectatic spots in the skin of the face and fingers. Two apparently suffered with gastric lesions as evidenced by repeated hematemesis. In 4 cases the onset was noted in childhood.

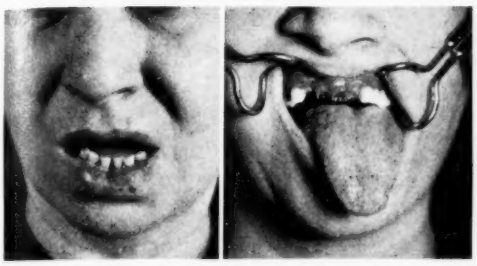
THERAPY

The clinical and pathological classification of hemangioma enumerated forms a basis for the following clinical study of the various therapeutic measures carried out in the attempt to bring about a cosmetically acceptable regression of the tumor:

Carbon dioxide snow. Carbon dioxide snow therapy yields satisfactory results in the management of the superficial, capillary lesions and is also useful in clearing the residual mottled areas remaining after sodium morrhuate therapy. The solid carbon dioxide snow is broken into small blocks and fashioned into suitable shapes. If the block is held in the fingers with gauze and pressed tightly against the lesion for from 7 to 10 seconds, the lesion may be obliterated without scarring. Several applications at intervals of 2 to 3 weeks are usually necessary.

The subfreezing temperature of the blocks is transmitted to the tissue and injures the endothelial cells causing thrombosis and fibrosis. Since penetration extends but a few millimeters into the tissue, only the flatter lesions can be treated in this way. Capillary lesions of a large surface area should be segmented and treated with several applications. Superficial ulceration results if applications are continued longer than 12 seconds.

Sodium morrhuate therapy. With the exception of the superficial capillary lesions and large inaccessible tumors, sodium morrhuate therapy is now the method of choice at Memorial Hospital. We have experimented with injections of many different sclerosing solutions and even boiling water, alcohol, and ferric chloride have been tried, but a 5 per cent solution of sodium morrhuate has been



Figs. 20 and 21. D.H. Hereditary hemorrhagic telangiectasia or Rendu-Osler-Weber disease. Characteristic minute purplish areas of telangiectasia in the mucous membranes of the nose, tongue and lips. The patient is a 47 year old female with a history of repeated epistaxis and hematemesis for years. There is a definite familial history.

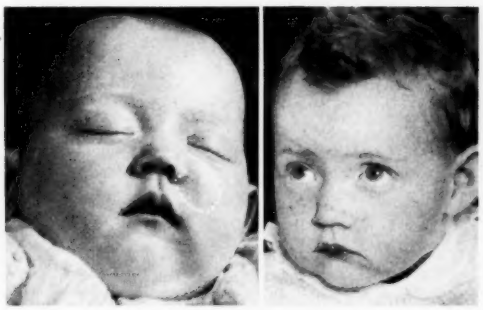


Fig. 22, left. K.O. Early racemose type of hemangioma successfully treated with sodium morrhuate injections. Mound-like, soft, bluish, pulsating mass 3 centimeters in diameter situated in the subcutaneous tissue of the face of a 5 month old child.

Fig. 23. Result 2 years later. Complete regression following 2 injections of sodium morrhuate.

found to be ideal and is now the only sclerosing solution used at our hospital for the treatment of hemangiomas. This solution has been used with increasing frequency since it was first employed by us for this purpose in 1935.

Sodium morrhuate has an advantage over quinine and urethane and other sclerosing agents in that it does not cause painful necrosis when accidentally injected into normal tissues. No phenomena of allergy or embolism has occurred in several thousand injections in children. One instance of sensitivity occurred in an adult.

The technique of injection is simple. A long hypodermic needle is introduced directly into the hemangioma mass. The amount of the solution injected varies, but, on the average, from ¼ to 3 cubic centimeters is used depending on the size of the lesion. If blood can be withdrawn into the syringe the entire amount is injected into that area; otherwise the solution is injected diffusely throughout the lesion. Compression is applied immediately and is maintained for 5 minutes. At intervals of from 2 to 5 weeks injections are repeated.

The action of the injected sodium morrhuate is to cause thrombosis and this is followed by sclerosis, atrophy, and absorption of the vessels. In order to be effective the agent does not necessarily need to come in contact with the vessel lining. In capillary hemangiomas the vessel lumen is too small and the stroma too abundant for sodium morrhuate to be efficiently injected.

The racemose, muscle, and large aggressive cavernous hemangiomas of the skin also resist this form of therapy because the fast flowing blood stream tends to sweep the solution out of the large sinuses before sclerosis or thrombosis can be effected. This can be prevented to some extent, however, by maintaining compression during and immediately after the injection of the solution.

The treatment is most strikingly effective with simple cavernous hemangiomas and stellate hemangiomas. The latter usually respond to a single injection of a few drops of the agent into the central arteriole.

Gratifying results are also to be had in the treatment of telangiectatic spots of Rendu-Osler-Weber disease. However, in this particular type of hemangioma the injection should be made in the submucosa alongside the telangiectatic area rather than directly into it, so that the solution will diffuse into the vessels. Injection directly into the vessel lumen invariably precipitates a hemorrhage. The treated area should be adequately compressed for several hours following an injection. New lesions should also be treated prophylactically before they start to bleed.

The typical large aggressive cavernous hemangiomas should be injected at intervals of from 5 to 7 days. If growth continues after 2 or 3 injections, the insertion of gold radon seeds should be begun immediately.

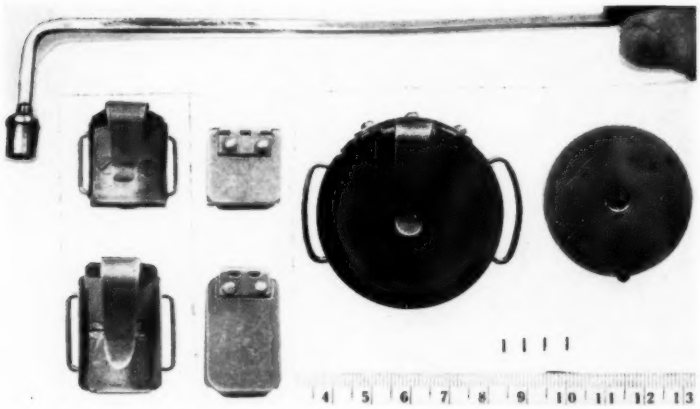


Fig. 24. Radon applicators used in the treatment of angiomas. Unfiltered radon bulb with long handle. Brass plaques for radon capsules with containers arranged to the left; container rests on 1 centimeter wooden block. The square plaque, threshold erythema dose of 225 millicurie hours; long plaque, threshold erythema dose of 250 millicurie hours; round plaque threshold erythema dose of 350 millicurie hours. Four gold radon seeds are shown above the scale.

Two patients with early pulsating racemose hemangiomas were successfully treated with sodium morrhuate injections alone (Figs. 22, 23). More frequently this method of treatment must be supplemented by radiation therapy and surgical ligation of contributory vessels, or even common carotid artery ligation. In 5 of the 7 remaining cases in our series, the lesions were controlled by a combination of surgery, interstitial radon, and sodium morrhuate injections; 1 patient died of hemorrhage and the other died as a result of tumor encroachment on the food and air passageway. In making the injection of sodium morrhuate into a racemose hemangioma, blood is withdrawn into the syringe and from 3 to 5 cubic centimeters of solution is discharged into the lumen of the vessel. Compression may be applied both during and after the injection.

Radiation therapy. Therapy by radiation may be administered externally with x-rays or radium. In either case the effect of radiation is directly on the vessel endothelial cells and causes obliteration followed by eventual sclerosis. If radium element or radon is employed all β radiation should be eliminated by proper filtration in order to prevent undue skin damage. Capsules containing radon are used at Memorial Hospital and are employed in square, long, and round brass plaques (Fig. 24), giving a filtration equivalent of three millimeters of brass. The applicator is held in a container on top of a wooden block which maintains it at a constant distance of 1 centimeter from the skin. The containers are easily taped to the skin with adhesive. These brass applicators find their chief use in the treatment of capillary hemangiomas which are too thick for carbon dioxide snow therapy, and also superficial small cavernous hemangiomas which resist sodium morrhuate therapy.

The group of 388 patients treated with the brass radon plaque alone constituted the largest group in the series. Careful analysis of the results of such therapy indicate that with the factors employed the optimum dosage for most hemangiomas is from 1 to 2 threshold erythema doses. When a dose of over 2.5 threshold erythema doses was used radiation fibrosis and telangiectasia often resulted. Many patients received 2 applications within 3 months with only fair results. It was later concluded that regression after 1 application of the plaque did not start for several weeks and that it continued for 6 months or more. It was obvious, therefore, that these growths had been overtreated. To obviate cumulative overdosage during such a characteristically long

regression period, only 1 application of between 1 to 2 threshold erythema doses should be given. A fraction of this dose may be repeated after 8 or 10 months, unless growth continues after the initial dose. In the latter instance, a second, smaller dose may be applied within 6 weeks.

Another type of radon radiation is administered with the "radon bulb" (Fig. 24). The equipment consists of a small radon filled glass bulb on the end of a long applicator. The glass bulb, 4 millimeters in diameter, has no filtration and, therefore, emits both β and γ rays. It is particularly useful in treating resistant superficial capillary lesions. A dose of from 30 to 100 millicurie minutes will often be sufficient to bring about a good regression. In 1 case of hemangioma of the vocal cord, the bulb was applied to the lesion for a few seconds through a laryngoscope with excellent regression.

For interstitial irradiation of angiomatous masses, we use small, radon-filled, hollow gold seeds 4 millimeters in length (Fig. 24) inserted through the bore of special needles. These gold seeds contain 0.5 to 1.5 millicuries of radon and are inserted well below the surface of the tumor and at least 2 centimeters apart. They are reserved for the most resistant hemangiomas and are especially well adapted for use in thick, bulky capillary or cavernous hemangiomas which require skin damaging doses of external radiation. Gold radon seeds should be employed immediately with rapidly growing hemangiomas which resist sodium morrhuate therapy and may also be used as an adjunct in treating the racemose angiomas. The size of the lesion determines the amount of radon necessary for its control.

The end-results obtained with high and low voltage roentgen-rays were disappointing. High, medium, and low voltage were used with varying factors, but many hemangiomas responded only fairly well. Numerous other observers feel that γ-radiation exerts a more marked effect on blood vessel endothelium and for that reason radium has the advantage over roentgen rays. If x-ray therapy is to be used it should be well filtered, low voltage radiation given at a skin target distance of less than 30 centimeters. One to one and a half threshold erythema doses may be given and if need be followed by a smaller dose when initial primary regression has ceased.

High voltage roentgen therapy seems to be ideal for the treatment of bone hemangioma. The growths in 3 patients with hemangioma of the lumbar vertebræ and 1 with hemangioma of the mandible were permanently controlled, and the patients were relieved of their symptoms by fractionated doses of x-ray. Treatment in all cases was given with the following factors: 200 kilovolts, 30 milliamperes, 50 centimeter target skin distance, and 0.5 millimeter copper and 2 millimeter aluminum filtration delivering 200 r. daily through small portals of less than 100 square centimeters. The total dose should be large enough to sclerose the angioma vessels but not large enough to inhibit bone repair. The average satisfactory total dose will usually be 1,200 to 1,600 r. per portal. Bone healing is evident in check-up roentgenograms by an increase in density and thickness of the bony trabeculae.

Ray maintains that large cavernous hemangiomas of liver can also be caused to regress with high voltage roentgen-ray therapy. High voltage x-ray is likewise indicated and highly successful in the treatment of hemangiomas of joints and synovia—lesions which can rarely be treated surgically without danger of infection or ankylosis (Bennett and Cobey). It is also indicated in inoperable extensive muscle angiomas and certain racemose hemangiomas.

There is no successful therapy for the metastasizing hemangioma, and palliative radiation alone is indicated.

For some years it has been noted at Memorial Hospital that hemangiomas are more sensitive to radiation and other forms of therapy in the early months of infancy. Evidence tending to confirm this observation was derived by analyzing a special group of cases in which treatment was administered by a single dose of radon with the square plaque. By this selection of cases, many confusing variables were eliminated. As shown in Table II, it was found that a higher percentage of good regressions was obtained in infants under 3 months of age and a definite decrease in the percentage of good regressions in patients

Fig. 25, left. W.L. Spontaneous regression of cavernous hemangioma of arm. One month old child with bulky, bluish, compressible hemangioma measuring 6 by 6 by 3 centimeters in the skin of the arm.

Fig. 26. Result 18 months later following spontaneous regression without treatment of any kind.

over 6 months of age. On the basis of these findings we have come to the conclusion that, in general, *the radiosensitivity of hemangiomas varies in inverse proportion to the age of the patient.* This fact should be called to the attention of our pediatric colleagues as a plea for early treatment.

At this point a word of warning regarding indiscriminate radiation therapy seems indicated. A series of cases as large as the present one is apt to uncover a number of contraindications to this form of therapy and poor results and treatment hazards are found which may surprise even those physicians experienced in this work. This is especially true if a satisfactory follow-up system of control is practised and the patients closely followed, not only during treatment but during the healing stage and for years afterward. Clinics without an adequate follow-up system report exceptionally good results and practically no complications or late sequelæ.

A study of results seems to indicate that radiation measures are hazardous and should be used with considerable caution in the treatment of hemangiomas in the following locations: (1) scalp, where radiation alopecia may result; (2) midline areas over the sternum or vertebræ, where ulceration results with even small doses; (3) breasts and genitalia where marked atrophy may occur; (4) long bones, particularly over the epiphyses, where premature ossification may occur leading to arrest of longitudinal growth; (5) areas, such as lips and vulva, where irritation is constant and radiation carcinoma may result; (6) areas adjacent to the eyes. In 7 of our cases there is ophthalmological evidence of early radiation

TABLE III.—BLOOD AND LYMPH VESSEL TUMORS—HEMANGIOMA—RESULTS OF TREATMENT

	Lesions treated No.	Per cent
Excision—surgical or electrical		
Good	83	91
Fair	7	8
Poor	1	1
Indeterminate	2	
Total	93	
Carbon dioxide snow		
Good	54	88
Fair	6	10
Poor	1	2
Indeterminate	15	
Total	76	
Sodium morrhuate		
Good	65	86
Fair	8	11
Poor	3	3
Indeterminate	10	
Total	86	
Combined physical—sodium morrhuate and snow		
Good	30	86
Fair	3	9
Poor	2	5
Indeterminate	6	
Total	41	
Combined radiation and physical		
Good	78	65
Fair	30	25
Poor	12	10
Indeterminate	9	
Total	129	
External radiation—radium		
Good	218	61
Fair	82	23
Poor	53	16
Indeterminate	35	
Total	388	
Interstitial radiation		
Good	89	59
Fair	47	32
Poor	13	9
Indeterminate	12	
Total	161	
X-radiation		
Good	13	48
Fair	6	22
Poor	8	30
Indeterminate	7	
Total	34	
Combination radiation—external and interstitial		
Good	33	57
Fair	19	33
Poor	6	10
Indeterminate	2	
Total	60	
No treatment	6	
Spontaneous regression	3	
Refused treatment	3	

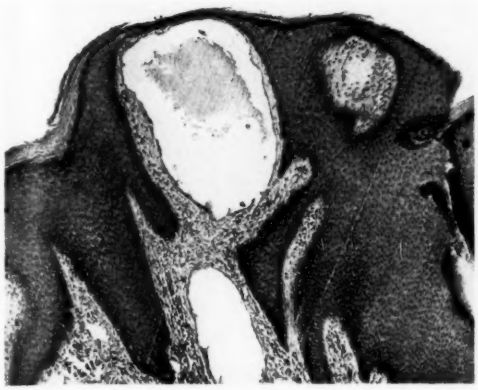


Fig. 27. Simple lymphangioma of skin. Section of typical thin walled, endothelium-lined, bleb-like structure which appears as purplish red skin vesicles. ×75.

changes in the lens. Fortunately, vision has not been impaired in any of the patients as yet and the changes would not have been detected unless a trained ophthalmologist regularly examined these children.

Radiation lens changes usually occur within 2 to 5 years and are readily detected by the characteristic ophthalmoscopic appearance of a small central, circumscribed, flake-like opacity in the lens capsule. It cannot be urged too strongly that in all the areas mentioned, and particularly in hemangiomas about the eyes, the possibilities of the carbon dioxide snow and sodium morrhuate injection therapy should be fully exhausted before radiation is used.

Surgical excision. Because it must necessarily be wide to obviate recurrence, surgical excision very often leaves unsightly scars. This, coupled with the discovery that in our series many individuals with angiomas have a tendency to form postoperative keloids, has placed the method in some disfavor. The group, presented under such a heading therefore, is a highly select group and the favorable results are misleading. Surgical excision is indicated for the small papillary tumors, bulky capillary lesions in areas where scars may be concealed by clothing and the resistant angiolipomas and for angiofibromas. Its main use is with the bulky "hemangioma hypertrophicum" where multiple stage excisions

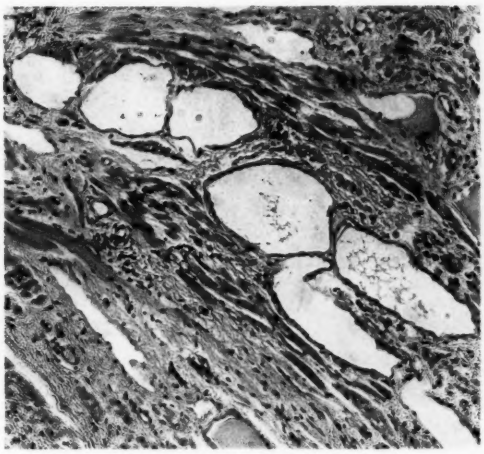


Fig. 28. F.R. Cavernous lymphangioma of tongue. Note large sinuses lined with single layer of endothelium containing lymph and invading and destroying muscle bundles. ×75.

may be necessary (Figs. 11, 12). These lesions are too cellular for injection therapy and too thick and aggressive for radiation measures.

Surgical excision is likewise the method of choice in the treatment of muscle hemangiomas (Jenkins and Delaney). Most of these growths have no capsule, and excision must be quite wide of tumor. Six of the 10 patients in this series were successfully treated by excision. In the 2 remaining successful cases treatment was by radiation alone at the ex-

Fig. 29, left. Cavernous lymphangioma of thigh. Male patient aged 12 years. Lesion present at birth. Recurred after excision. A bulky, spongy, compressible mass 25 by 15 by 8 centimeters with typical purplish red skin vesicles.
Fig. 30. Result 3 years later following radiation and excision.

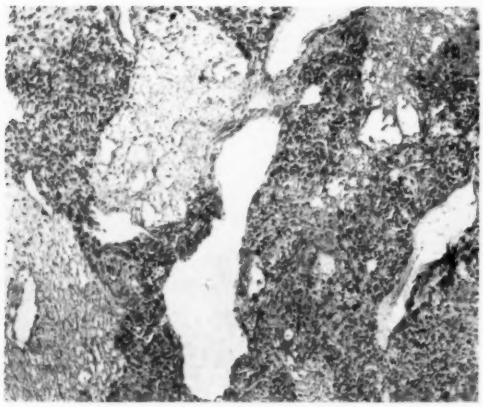


Fig. 31. M.S. Hypertrophic or cellular type of lymphangioma. Large lymph filled sinuses surrounded by masses of proliferating endothelial cells. Lesion noted deep in the thigh of a 40 year old female as a large encapsulated solid yellowish mass. Extension occurred after excision. ×75.

Fig. 32, left. Diffuse systemic hemolymphangioma of leg. Five month old child with diffuse mottled bluish, compressible lesion of entire leg. Note unusual lymphangiomatous skin vesicles associated with deep cavernous hemangioma. Similar angiomatous process noted in sigmoid at operation.

Fig. 33. Photograph 6 years later following a course of roentgen therapy and sodium morrhuate injections.

pense of some skin damage. Surgical excision is the only method worth considering in the treatment of hemangiomas of the gastrointestinal tract (Brown).

Ligations of the afferent vessels supplemented by sodium morrhuate injections and, in severe cases, various radiation measures are to be considered for the diffuse systemic type of hemangioma. The results are disappointing.

Port wine stains do not respond well to radiation, carbon dioxide snow, or injections of sodium morrhuate solution. Upon reviewing the microscopic section (Fig. 18) the reason for such radioresistance is evident, since the telangiectatic, scattered vessels possess a thin, flattened vessel endothelium of adult type as contrasted with the thick celled endothelium of the sensitive embryonic type. There is no evidence of endothelial proliferation whatsoever, and, like most static lesions, the port wine stain is consistent in its therapeutic resistance. Small lesions may be excised, but larger lesions can be improved cosmetically only by covering them with proprietary cosmetic paste such as Covermark.

Occasionally a hemangioma may regress spontaneously, usually following ulceration or infection. Three remarkable spontaneous regressions occurred in this series. Such regressions may be explainable by chance thrombosis of the tenuous afferent vessel. In 1 of these cases the regression was complete in a few months (Figs. 25, 26).

RESULTS OF THERAPY

In every case in this series the treatment has been analyzed and critically appraised. Cases in which therapy was not finished or in which the records were incomplete are considered "indeterminate" and are not included in the figures.

The various therapeutic methods employed are listed in 10 categories (Table III). Most of the headings are self-explanatory, but a word should perhaps be said about several of the later divisions. "External radon radiation" applies only to brass plaques containing radon-capsules and radium bulb applications. "Interstitial radiation" refers to the lesions in which gold radon seeds were inserted into the substance of the tumor. "X-radiation" includes high, medium and low voltage roentgen therapy. "Combination radiation" applies to all combinations of external radium with roentgen and interstitial radiation.

Fig. 34.

Fig. 35.

Fig. 36.

Fig. 34. G.H. Cystic hygroma of the neck. Two month old female. Lesion present at birth. Successfully excised.

Fig. 35. Gross specimen 6 centimeters in diameter with attached skin.

Fig. 36. Cut section showing multiloculated, thin walled cysts containing clear serous fluid. Examination of the specimen showed that all of the locules were in communication with one another.

The effectiveness of therapy was judged "good," "fair," or "poor," according to the cosmetic results obtained and the regression of the lesion. The term "poor" is applied, in addition, to all cases in which there were recurrences or complications.

In looking over the chart giving the results of therapy, it will be seen that the lesions excised surgically show the highest percentage of good results (91 per cent), but, as noted earlier in the discussion, this is a highly select group of cases. Postoperative keloid formation accounts for most of the unfavorable results in this group.

The results of the carbon dioxide snow treatment were also impressive; 88 per cent of the cases showed good response. The unfavorable results invariably followed too long an application with consequent ulceration and scarring.

Being our method of choice, sodium morrhuate injections are given a trial for the first few weeks in all types of hemangiomas, including even the capillary type. Rapidly growing lesions which do not respond to 2 or 3 injections should be subjected immediately to radiation or surgical intervention regardless of the location of the tumor. Results were good in 86 per cent of all the cases treated with sodium morrhuate. Improper selection or over-injection accounts for the less favorable results.

The "combined physical" group yielded 86 per cent good results. Generally sodium morrhuate was the primary agent, and carbon dioxide snow was used later to eradicate the residual skin mottling.

A sharp drop in the percentage of satisfactory results is noted in the group of cases in which radiation was employed. This is to be expected since radiation is reserved for the more extensive and the more resistant lesions. In some cases, however, over-irradiation resulted in telangiectasia or fibrosis.

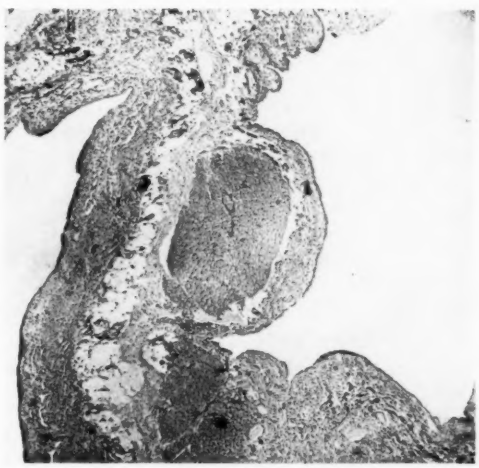


Fig. 37. A.B. Cystic hygroma of neck. Note muscle bundles in center of field, circumscribed on both sides by invading thick walled endothelial lined cysts. Lesion present at birth in the posterior neck of a one year old child. Slow growth. Excised successfully. ×65.

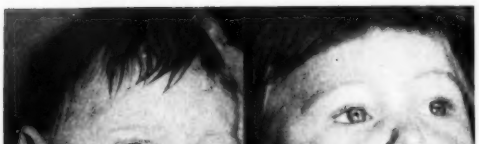


Fig. 38, left. R.G. Cystic hygroma of neck. Six weeks old infant with soft cystic hygroma 5 centimeters in diameter in the posterior triangle of the neck. It was noted at birth. Growth was slow. Serous fluid aspirated and two injections of sodium morrhuate administered.

Fig. 39. One year later showing complete regression. No recurrence at the present time, 2 years later.

The "combined radiation and physical" therapeutic measures were employed in an aggressive group of hemangiomas which successfully resisted the physical agents, usually sodium morrhuate. Good results here were excusably lower (65 per cent). Nevertheless, in many cases the injections helped to the extent of causing some sclerosis, thereby reducing the supplementary radiation dose necessary for complete regression.

The figures for "external radon radiation" include the group of cases which received single doses of irradiation and those which were given divided doses. The results of the combined techniques were good in 61 per cent of the cases. Breaking down this figure it was found that the single dose technique yielded over 80 per cent good results and that the combined percentage was lowered chiefly by the poorer results obtained when multiple doses were employed. Invariably, the second dose had been given before a 2 month interval had elapsed, and thus was prematurely given in so far as the primary regression had not ceased. It was decided, therefore, that cumulative overdosage was responsible for the unfavorable results.

Good results were obtained in only 59 per cent of the patients who were treated by interstitial radon gold seed radiation. The results are better than the figures would seem to indicate, however, for the hemangiomas treated by this method were either the aggressive, cellular lesions, or the extensive, deep cavernous ones.

The group treated by "x-radiation" responded least favorably. Good results were obtained in only 48 per cent of the cases. Poor results were higher than in any of the other methods of therapy—30 per cent of the series. This unfavorable response can be explained by several factors. First, most of the lesions were the refractory, diffuse, systemic type which respond poorly to any form of treatment. Second, filtration was probably inadequate in some cases and undoubtedly there was overdosage in others. There is little doubt that hemangiomas respond less favorably to roentgen rays than to the harder γ-rays of radium or radon.

Results of the "combined radiation" series were good in 57 per cent of the cases. This is an acceptable figure when it is considered that only the aggressive, extensive lesions were treated by this method of therapy.

"Spontaneous regression" without ulceration occurred in 3 cases and in 1 instance the regression was quite spectacular. Since there is no way, however, of knowing which tumors will spontaneously regress, all should be treated and, if possible, treatment should start immediately after onset. Untreated lesions often ulcerate and bleed, but even when they do not, the growths steadily become more resistant to therapy and are more likely to recur after treatment.

RECURRENCES

Forty-three patients, roughly 4 per cent of our series, had recurrences after treatment either at Memorial Hospital or elsewhere and most of the recurrences took place after surgery. Practically all the patients with recurrences were adults with long standing lesions.

LYMPHANGIOMA

Lymphangiomas, like hemangiomas, may possess marked growth capacity and they are not, as was once commonly supposed, dilated, static, normal lymph channels. Some observers state that lymphangiomas have no anastomoses with surrounding lymph vessels.

It is generally agreed that lymphangiomas have their origin in displaced fetal cells of the lymphatic system.

A group of 41 cases of lymphangioma comprises the material studied in this report. Sixty-one per cent of the patients had the tumor at birth and 95 per cent were noted before the age of 10 years. Sex distribution was almost equal, the female percentage, 58 per cent, being only slightly higher than the male.

The anatomical distribution was considerably different from that of the hemangiomas. Fifty-two per cent of the lymphangiomas were located on the head and neck, 44 per cent on the extremities, and 4 per cent on the trunk.

CLASSIFICATION

Wegner's original classification of lymphangiomas as simple, cavernous, and cystic, is commonly accepted. In order that the classification be completely satisfactory in a clinicopathological consideration of lymphangiomas, however, several additions must be made. In the present study, the classification has been enlarged to the following five divisions: (1) simple lymphangioma, (2) cavernous lymphangioma, (3) cellular or hypertrophic lymphangioma, (4) diffuse systemic lymphangioma, and (5) cystic lymphangioma or hygroma.

1. *The simple lymphangioma* (Fig. 27) is an uncommon, poorly defined disease entity which borders on simple lymphangiectasia. Its channels are superficial, scattered, and thin walled. The lesions are small, well circumscribed, and present a shiny wart-like surface. They show little tendency to grow.

2. *The cavernous lymphangioma* (Figs. 28, 29, 30) usually constitutes the majority of lymphangioma cases. This form is composed of dilated lymphatic sinuses usually filled with lymph, but sometimes empty, and in rare instances filled with blood. The lining endothelium is flat, and in active lesions may be several layers in thickness. The stroma varies in amount and may be found to contain diffuse lymphoid or smooth muscle tissue, attesting to the embryonic origin of the tumor from mesodermal "rests." A mixed form with fat or fibromatous elements also exists. Solid endothelial "buds" can frequently be seen invading surrounding fat and muscle.

A cavernous lymphangioma usually involves skin or subcutaneous tissues, but it may extend into mucous membranes of the oral cavity or between the muscle septa of the neck. The superficial skin lesions appear as multiple brownish or red vesicopapules, or even wart-like papillary lesions which exude lymph when traumatized. The deeper growths present an appearance of multiple, diffuse, compressible nodules or masses with little or no change in the overlying skin. This growth occurs commonly about the face and in the oral cavity. Involving the tongue, it produces great hypertrophy—macroglossia; in the lips it is known as macrocheilia, and in the cheek as macromala. Other sites are the extremities and the retroperitoneal and mesenteric areas.

3. *The cellular or hypertrophic lymphangioma* (Fig. 31) is simply a more active type of local cavernous lymphangioma and has a minimum of sinuses and an abundance of proliferating endothelium. It is slow growing and uncommon. Clinically, it appears as a circumscribed, superficial structure of fibrous consistency.

4. *The diffuse systemic lymphangioma* (Figs. 32, 33) generally involves an entire extremity. The process is slow and may continue for many years. Clinically, the extremity appears hypertrophied and overstuffed. The skin may be normal or studded with papules. The deeper tissues have a spongy consistency. Microscopically, the lesion is generally found to be cavernous, but it is more active than the simple cavernous type. Frequently, the channels contain blood, and the tumor may simulate a cavernous hemangioma, but clinically its behavior is that of a lymphangioma. Also, the vesicopapules have a bluish hemorrhagic hue, whereas hemangiomas are not associated with such bleb-like structures.

5. *Cystic hygroma or the cystic type of lymphangioma* is a distinct disease entity and must not be considered merely as a dilated or cystic cavernous lymphangioma. The tumor definitely develops from lymphatic tissue, and for this reason is included in our classification.

Hygromas are usually found in the neck, but occasionally they are located in the axilla,

and, in rare instances, in the retroperitoneal tissues (Gerster) or in the groin. The cystic mass is compressible, thin walled, and generally multiloculated (Figs. 34–37). It is lined with endothelium and contains serous fluid. The lesion usually transilluminates well, thus making it possible to distinguish a hygroma from other cystic masses occurring in the neck, such as a branchiogenic cyst.

Hygromas are generally present at birth and grow very rapidly. In the neck the growth often extends into the axilla or down into the mediastinum causing symptoms of compression. The remarkable power of growth which these cysts possess may be attributed to their origin from the same primitive jugular sacs (McClure and Silvester), or initiation centers from which the lymphatic system develops. Two such jugular sacs are situated in the neck adjacent to the internal jugular vein, 1 in the lumbar retroperitoneal area and 2 in the iliac area. These locations correspond exactly with the anatomical sites at which hygromas are usually found. The process by which hygromas develop was not well understood until Goetsch demonstrated that solid endothelial sprouts extend into surrounding tissue, encircle vital structures, secrete lymph, and canalize back to the parent cyst.

Two hundred and twenty-five cases of hygroma have been reported in the literature. The Memorial Hospital series includes 14 cases, an incidence of 1.4 per cent of the total number of blood and lymph vessel tumors reviewed in the present study. Nine of the patients were male and 1 was a Negro. In 11 cases, or 79 per cent, the cyst was present at birth and the remaining lesions developed at the ages of 4, 6, and 15 years.

The anatomical distribution of the lesions supports the lymph-sac theory of origin. Thirteen, or 93 per cent, of the lesions were located in the neck and the other was situated in the axilla. This fact is particularly interesting when it is remembered that only 2 per cent of all other types of lymphangioma were located in the neck. In 2 of our cases, roentgenograms of the chest were made and revealed mediastinal shadows suggesting disease extension into that area.

TREATMENT OF LYMPHANGIOMA

In general, surgical excision affords the best prognosis in the treatment of lymphangiomas even though unsightly scars are likely to form and there is a marked tendency toward postoperative keloid growth. The results were good in 77 per cent of the 13 patients in our series in which wide excision was performed. In 4 of the cases there was a definite recurrence which was controlled by a second excision. Routine postoperative radiation is helpful in controlling recurrences and in preventing keloid formation. If surgical excision must be incomplete, a fairly large dose of interstitial radon is necessary for control of the irremovable portion.

Lymphangiomas are radioresistant and for this reason radiation therapy alone is not usually indicated. With but one exception, all cases in which treatment was by radiation, a dose was required which caused marked skin damage. Good results were obtained in only 35 per cent of the 18 cases in which radiation treatment was used, and in 25 per cent the results were definitely poor.

Because of the nature of the disease, radiation remains the method of choice, however, in treating the diffuse systemic lymphangiomas which affect an entire extremity. High voltage therapy is generally used at 50 centimeter target skin distance with high filtration.

Sodium morrhuate injections have no effect whatsoever in the treatment of lymphangioma, with the exception of cystic hygroma.

Lymphangiomas show a marked tendency to recur. Seventeen, or 41 per cent of our cases, were recurrences after treatment elsewhere. Our own recurrence rate was 12 per cent. Most of these were cases of surgical excision. An analysis of our records show that, as with hemangiomas, this tendency toward recurrence increases with the age of the patient (Table IV).

Cystic lymphangiomas (hygromas) are relatively radioresistant. Regardless of the method of treatment, the results are often not satisfactory and the general mortality rate is high. Secondary infection of the hygromatous mass may follow an upper respiratory infection and lead to an acute toxemia or septice-

TABLE IV.—BLOOD AND LYMPH VESSEL TUMORS —ANALYSIS OF RECURRENCES

Number of cases with recurrence	
Hemangioma	43[1]
Lymphangioma	17[2]
Hygroma	1[3]
Total	61

	Cases	Percent of entire age group	Cases in age group
Hemangioma			
Age incidence of recurrence			
Under 1 year	3	0.5	565
Between 1 and 10 years	13	7	195
Between 10 and 20 years	9	17	53
Over 20 years	18	10	188
Lymphangioma[4]			
Under 1 year	0	0	4
Between 1 and 10 years	4	25	16
Between 10 and 20 years	7	58	12
Over 20 years	6	66	9
Hygroma			
Following sodium morrhuate therapy	1		

[1] 4 percent of all hemangiomas.
[2] 41 percent of all lymphangiomas.
[3] 7 percent of all hygromas.
[4] Extension or recurrence after treatment elsewhere, 17 or 41 percent; recurrence after treatment at Memorial Hospital, 4, or 10 per cent.

mia. This is particularly true of the cervical hygromas which are located in the area into which infections of the nasopharynx, the pharynx, and the tonsils normally drain. It is also noteworthy that postoperative infections frequently occur, due, no doubt, to a derangement of the lymphatic barriers.

In a review of the 126 cases, Dowd noted a mortality of 47 per cent in the cases of cervical hygroma treated by surgical procedures of various kinds. Figi, of the Mayo Clinic, reported 13 patients treated by radiation alone; of these 7, or 54 per cent, died of infection during treatment.

Of the 13 cases in our series, surgical excision was performed in 7 with a good result in 5. In 1 case of axillary hygroma, the lesion was not completely removed because of the extent of the tumor. The remaining case was an unusually large cervical hygroma which extended into the mediastinum; this patient died soon after operation, thus making the operative mortality 7 per cent.

Because of the ever present danger of postoperative infection, we have striven to institute a more conservative form of therapy. Following Harrower's suggestion, in 7 of our cases we routinely aspirated the hygroma under the strictest sterile precautions and injected from 1 to 3 cubic centimeters of a 5 per cent sodium morrhuate solution. Four cases, 57 per cent, showed good results (Figs. 38, 39), but in 2 cases regression was only fair and excision was necessary. In the remaining case, gold filtered radon seed implantation was required to complete the regression.

In the cases in which we have had an opportunity to try it, we believe the results justify the recommendation that sodium morrhuate therapy be given a trial in the treatment of all hygromas. If it fails, one must attempt surgical excision and if excision is necessarily incomplete then radiation measures may be attempted. Injections should be given as early in the course of the disease as possible for the following reasons: (1) hygromas are more sensitive to therapy and are more likely to be unilocular early in the course of the disease; (2) while Goetsch suggests postponement for several months until the patient is a better surgical risk, it should be remembered that the earlier the cyst is treated the less opportunity there is for it to invade and circumscribe vital structures; (3) with sodium morrhuate therapy there is not the high mortality associated with surgery or radiation; (4) postponement increases the danger of mortality from secondary respiratory infections.

SUMMARY

1. A comparative clinical, pathological, and therapeutic study of 1,056 patients with 1,363 individual blood and lymph vessel tumors is reported.

2. Benign tumors of blood and lymph vessels have a common origin in embryonic sequestrations of mesoderm, grow in identical fashion, demonstrate similarities in response to various therapeutic agents and, therefore, are studied as a single group.

3. A suggested classification of blood and lymph vessel tumors is based on the clinical and pathological aspects of these lesions in so far as they serve the dictates of therapy.

4. Methods of therapy are appraised and their indications and hazards pointed out. Evidence is offered to support the contention

that hemangioma is more sensitive to radiation in the first 3 months of life, and that angiomas in general recur less frequently when treated early.

5. A conservative method of treating *hygroma* is advocated and outlined. Injection therapy immediately at onset is urged in order to afford the tumor less opportunity to circumscribe vital structures and also to obviate the danger of upper respiratory infections draining into the tumor and possibly causing death. Surgical excision with its high mortality is recommended after the conservative method has failed. Radiation therapy is recommended for inaccessible extensions of the hygroma.

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ACUTE INTESTINAL OBSTRUCTION

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NOTWITHSTANDING the improvements made in surgical technique and the additions made to the therapeutic armamentarium for the treatment of acute intestinal obstruction, the mortality in this feared condition has not been materially reduced. Once the symptoms and signs suggestive of interruption of continuity of the intestinal lumen are present, a rapid and accurate diagnosis should be made, thus permitting the institution of the proper form of treatment. An investigation has been made of all cases of acute intestinal obstruction in which surgical treatment has been given at the Mayo Clinic, over a period of 5 years, to determine the various etiological factors and the relationship of treatment to mortality.

Excellent classifications of the different causes of acute mechanical obstruction of the intestine have been presented by many authors. A recapitulation of the causes of obstruction reviewed in the present series will be found in Table I. It should be noted that some of the congenital etiological agents do not appear in this collection of cases.

Incarcerated or strangulated external hernias are the most frequent cause of acute intestinal obstruction. These may be divided anatomically into inguinal, both indirect and direct, femoral, umbilical and ventral, and prolapse through the site of a previous surgical procedure. External hernias accounted for the symptoms in 147, or 44 per cent, of the 335 cases of acute intestinal obstruction reported by McIver (8). In the series reported by Morris and Johnson, 129 instances, or approximately 54 per cent, of the same syndrome were caused by external hernias. Four per cent of all patients having hernia, admitted for treatment in a period of 13 years were found to have an associated intestinal obstruction. Various types of external herniations accounted for 74, or 53 per cent, cases of acute interruption of intestinal continuity seen at the clinic from 1935 to 1939, inclusive.

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The syndrome presented by external hernias that produce obstruction is characteristic. Abdominal pain, crampy or steady in nature, nausea, vomiting, and constipation associated with an irreducible tender mass, are the cardinal symptoms and signs. Distention is usually mild in degree, and the lower portion of the ileum is the most frequent site of obstruction. Incarceration and strangulation must be sharply distinguished from one another since the treatment and prognosis differ greatly in these 2 conditions. The former may exist for long periods without symptoms. Once the lumen has been encroached on to some degree, or the vascular supply to the region has been interfered with, therapy must be undertaken immediately. Small internal abdominal rings offer a great chance for strangulation. "Reduction *en bloc*" should be sharply criticized for non-viable omentum and intestine may unwittingly be returned into the abdominal cavity. Protrusions of the omentum and incarceration or strangulation of the adipose tissues present an acute picture and it is often difficult to decide whether bowel is present in the sac. Surgical procedures should decide the question. Strangulation has been found to occur more frequently in association with femoral and umbilical hernias than with inguinal protrusions, although the occurrence of the two former types is infrequent as compared with that of the latter.

Marked tenderness over the sac of an irreducible hernia, associated with signs of obstruction, symptoms of toxemia, and an increase in the number of leucocytes, points to strangulation of the bowel. In McIver's (8) series of 147 cases, males were subject to strangulated external hernia about twice as frequently (100) as females (47) were. These statistics are in close accord with the

TABLE I.—CAUSES OF ACUTE INTESTINAL OBSTRUCTION IN CASES ENCOUNTERED AT THE MAYO CLINIC, 1935–1939, INCLUSIVE

	Cases
External hernia	
Indirect inguinal	43
Direct inguinal	3
Indirect and direct inguinal (combined)	1
Umbilical	6
Femoral	11
Ventral	8
Prolapse through site of previous operation	2
Internal hernia	7
Adhesions and bands	23
Volvulus	9
Intussusception	10
Mesenteric thrombosis	3
Gall stones	2
Congenital mesenteric cysts	2
Diverticulitis	2
Carcinoma	4
Total	136

present group of 74 patients, of whom 54 were males and 20 were females.

Mortality in external strangulated hernia is most intimately associated with the degree of embarrassment of the blood supply to the affected portion of bowel. Some interference with circulation will be present with every such hernia, but frequently the bowel will be considered viable on release of the obstruction. The question of viability may be more quickly decided at operation if the patient is given 100 per cent oxygen and the color of the bowel is watched closely. When doubt exists, the loop of bowel should be exteriorized. In 42 cases of the total group, the viability of the bowel was strongly questioned at the time of operation (Table II). Fortunately the bowel was considered viable in the great majority of patients. Most of the deaths occurred when necrosis of the bowel had occurred, thus necessitating procedures other than release of the obstruction and repair of herniation site.

The large number of cases in which it was questionable whether the blood supply to the affected loop of bowel was adequate are readily explained. Special types of acute surgical conditions seen at the clinic are not unlike those encountered in any large medical center inasmuch as the greater number of patients with acute intestinal obstruction owing to hernia are cared for by the local practitioners as emergencies, whereas patients critically ill are sent to the clinic.

TABLE II.—EXTERNAL HERNIAS CAUSING INTESTINAL OBSTRUCTION, IN WHICH A SUFFICIENT BLOOD SUPPLY TO LOOP OF BOWEL WAS QUESTIONABLE AT THE TIME OF OPERATION

Type of hernia	Total patients		Adequate blood supply questionable	
	Males	Females	Males	Females
Indirect inguinal	42	1	22	0
Direct inguinal	3	0	2	0
Indirect and direct	1	0	0	0
Umbilical	1	5	1	2
Femoral	2	9	2	7
Ventral	3	5	1	3
Prolapse	2	0	2	0

Internal hernias, by definition, should include all of those protrusions of the contents of the abdomen through intraperitoneal pouches or openings of congenital or traumatic origin. The number of such hernias is small in contrast to the external protrusions that take place through the abdominal wall. In reporting a case of prevesical hernia, Stalker and Gray have stated that only 29 internal hernias have been encountered at the Mayo Clinic since 1910. These were classified either anatomically or on the basis of an associated etiological factor as: 8 cases of hernia through the transverse mesocolon, following gastro-enterostomy; 7 of paraduodenal hernia; 4 of mesenteric hernia; 3 of malrotation of the colon; 3 of hernia through the broad ligament; 2 of retrocecal hernia; 1 of hernia through the foramen of Winslow; and 1 caused by fibrous bands. Twenty-five patients had symptoms referable to the hernia, but these were vague and not diagnostic. Twenty-three had some degree of obstruction of the small intestine.

If this type of hernia did not become manifest through partial or complete interruption of the continuity of the intestinal lumen, the majority of such hernias would pass without recognition, for they are unheard of until their presence is heralded by some complication, such as incarceration, volvulus, or strangulation. Internal hernias that occur as a result of abdominal operations are now seen less frequently than formerly owing to the taking of proper precautions at the time of such surgical procedures. An example of such a preventive measure is the suturing of the stomach to the opening in the transverse

mesocolon when posterior gastro-enterostomy is performed, to prevent herniation of the small intestine into the lesser peritoneal sac.

Therefore, the more important internal hernias at present are those resulting from congenital defects. Although few in number, these hernias assume considerable clinical significance in consequence of the high incidence of acute intestinal obstruction with which they are associated. Seven patients with internal hernias and acute intestinal obstruction have been seen at the clinic during the 5 year period under consideration. Figure 1 depicts the mechanism of a prevesical hernia recently observed and reported by Stalker and Gray. A rent in the omentum (Fig. 2) was the etiological factor in a second case.

Second only to external hernias as a cause of intestinal obstruction are bands and adhesions. These may be either congenital or the result of inflammation or trauma. Many are very dense in nature. A small portion of the omentum may become attached to the bowel or to the abdominal wall and act as an obstructing band. Likewise, a Meckel's diverticulum may be the etiological factor as in one case in the present series. A fibrous band may be all that is left of the structure, or adhesions may form around the anomaly due to inflammation, with the free end of the diverticulum anchored to the mesentery or to some other structure.

McIver (9) has divided his group of cases of intestinal obstruction, the result of bands and adhesions, into three groups: early postoperative, late after operation, and those without operation. As an etiological factor, McIver (9) found that appendectomy with resultant adhesions heads the list in the early postoperative group. Strangulations are not common among this particular group of intestinal obstructions which usually involve the lower part of the small intestine. However, strangulation is more frequent in the group occurring late after operation and appendicitis is the most common cause.

Twenty-four patients who were suffering from acute intestinal obstruction, the result of bands and adhesions, were seen at the Mayo Clinic during the period under consideration. All but one had been subjected to operation previously. Twelve had had pelvic operations of various types whereas 6 had had appendectomies performed. It is significant that 6 patients of the total of 24 had some degree of necrosis of the intestinal wall. All patients in this last group had been operated on previously. The jejunum was involved once, different portions of the ileum four times, and a Meckel's diverticulum occurred in 1 instance. All the patients subjected to previous operation experienced obstruction in the late period, that is at least 10 days after operation. The pathological condition present in one such case is shown in Figure 3. In some instances, a period of years had elapsed since the previous surgical procedure. Operative intervention in these cases at the time when the obstruction was treated, varied markedly, depending on the individual circumstances. The surgeon tended to be conservative rather than radical.

Volvulus of various portions of the intestinal tract accounts for only a small number of acute intestinal obstructions. Nine patients comprised this entire group and in marked contrast to other reports, the small intestine was involved more frequently than the large intestine. The jejunum alone was involved once, the ileum alone five times, and both the jejunum and ileum were involved in one case. Ninety-five per cent of the small intestine had become twisted in the remaining case in which the small bowel was involved and the ileocecal region was involved in the last case in the group. Viability of the bowel was so poor in 3 cases that resection had to be undertaken. Bands and adhesions that had fixed some portion of the intestine served as a center for rotation in the majority of cases. With such rotation, an isolated loop which rapidly distends is formed. The vessels are compressed to varying degrees and, with marked embarrassment of the blood supply to the segment, necrosis of the bowel occurs.

Intussusception is essentially a disease of infancy and early childhood. In an interesting summary of 400 cases by Perrin and Lindsay, the authors found that about 65 per cent of the patients were males, and that 78.5 per cent were less than two years of age. Two hundred and three of the 400 patients

had intussusception between the ages of 5 and 9 months. By far the greatest majority of lesions involved the ileocecal region; the authors classified 39.0 per cent of their cases as ileocecal and 31.5 per cent, ileocolic. The intussusception reached the rectum more frequently in the former group, but the distance traveled does not necessarily influence the prognosis too greatly. The chief factor in the determination of mortality is the duration of the intussusception. Death occurred in 34.75 per cent of the 400 cases.

All of the 10 patients in the present series were 2 years of age or less, except 2 who were aged 4 years and 6 years, respectively. Fifty per cent of the patients who had intussusception were between 5 and 10 months of age. Pain in the abdomen, vomiting, and bloody stools are usually present, and occasionally a rectal mass can be felt.

According to McIver (9), the characteristic picture is not seen in the adult and the diagnosis is often made only at operation. The small intestine is frequently involved and all cases should be investigated for some etiological factor, especially when the patient is an adult. In one of the cases in the present group, a Meckel's diverticulum was the starting point of the intussusception (Fig. 4).

As one of us (C.W.M.) has pointed out previously, treatment of acute intussusception is primarily surgical and reduction of the intussuscepted bowel is possible in less than 24 hours and usually in less than 36. A low mortality is attendant on such a procedure. Immediate resection carries a high mortality. Reduction after 36 hours is dangerous, and consideration should be given to fixation to prevent progression of the intussusception and to ileocolostomy around the affected portion of bowel.

Moore has stated that from available records between 1 and 2 per cent of all intestinal obstructions are the result of gall stones, and he has estimated that about 400 cases had been recorded in the literature before 1925. In spite of the prevalence of cholecystic disease, gall-stone ileus is remarkably infrequent. It should be noted that the cause of obstruction is usually not suspected before operation and a history of chronic cholecystitis is of no value. The obstruction may be caused by the stone itself being too large to pass onward, by producing an intussusception of the bowel, or by becoming embedded in the wall of the gut and secondarily closing the lumen. Usually, the gall stone gets into the intestinal tract through a cholecystenteric fistula, and then travels onward to rest in the terminal portion of the ileum in the majority of cases. The fistula may not remain patent. Only 2 of the 136 cases of acute intestinal obstruction in this series were the result of gall stones.

Likewise, a few cases of mesenteric thrombosis will be found in most large series of acute intestinal obstruction. Although the large infarcts of the intestinal tract offer a hopeless prognosis, small infarcted regions, if recognized early, can be handled surgically. The making of a distinction between arterial occlusion and venous thrombosis will help in diagnosis and prognosis, although simultaneous involvement of both types of vessels may also occur. Jackson and others have been able to collect 214 cases and have reported that 61 per cent were arterial and 39 per cent venous in nature. Sixty-four per cent occurred in males and the remainder in females. Larson found that the occlusion was arterial in 39 per cent, venous in 44 per cent, and both arterial and venous in 17 per cent. The changes in the bowel wall depend on the size of the vessel occluded, the rapidity of occlusion, and the adequacy of the collateral circulation.

When an acute occlusion of the mesenteric artery has occurred, sudden colicky pain, vomiting, blood in the stools and vomitus, early abdominal distention, a tender abdomen, and an increase in number of leucocytes in the circulating blood are present. The condition is rapidly fatal and early operation is imperative.

Much more amenable to operation in the earlier phases are the patients who have mesenteric venous thrombosis in which progress of the disease is relatively slow. Pain of a colicky nature is present, but abdominal rigidity is minimal in proportion to the abdominal tenderness. The number of leucocytes per cubic millimeter of blood is relatively low during the initial period of the disease, but it

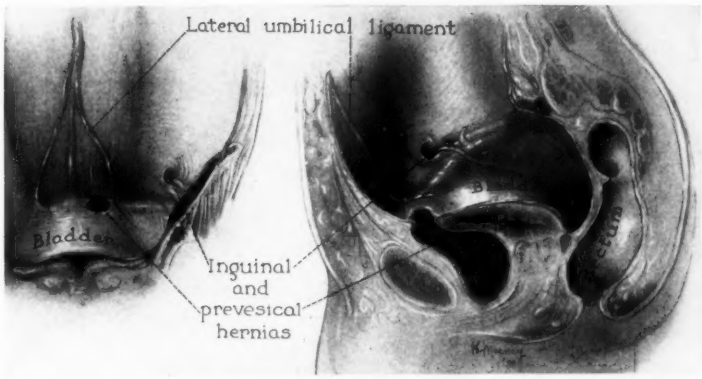

Fig. 1. A prevesical hernia.

rises rapidly later. Occult blood is uniformly present in the stool and occasionally, blood may be noted in the vomitus. An edematous discolored intestine is found at operation, but the muscular structure remains viable and peristalsis can be produced. If only a small region is involved, the collateral circulation may be sufficient to prevent further damage. However, all such sites should be removed to avoid (1) the danger of a possible subsequent perforation, (2) stenosis of the wall necessitating perhaps another operation later, and (3) formation of adhesions and later obstruction.

Massive involvement of the intestine was present in 2 of our cases, and the abdomen was closed as an exploratory procedure. Resection of about 15 inches (37.5 cm.) of jejunum and a side-to-side anastomosis was necessary for the other patient. This case was recorded previously by Clagett and Gray.

Symptoms usually of purely mechanical obstruction are caused by mesenteric cysts. In 1934, Hugh-Jones analyzed 55 cases and found that 85 per cent of the cysts involved either the cecum or the ileum. An excellent summary of the material relative to enterogenous cysts has been made by Dockerty, Kennedy, and Waugh. Cysts in the terminal portion of the ileum are usually found during the first year of life as is illustrated by the case they reported. Mesenteric cysts are discovered in an older age group because obstruction occurs at a later date. Illustrative of this latter group is a 9 year old patient in whom obstructive symptoms were caused by cysts which necessitated resection of a portion of the jejunum with end-to-end anastomosis, with excellent results in both.

Carcinoma of the bowel, particularly of the sigmoid and diverticulitis of the same region are relatively infrequently encountered causing acute intestinal obstruction. A study of the majority of such cases indicates that the obstruction is rarely acute, if the strict definition of the latter is used. The clinical cause may be comparatively prolonged before complete mechanical interruption of intestinal continuity is effected. The history, physical signs, and laboratory findings are somewhat characteristic and do not need special elucidation at this point. Occasionally, patients with short histories and signs of acute obstruction are encountered, and it seemed that there might be included in this series 5 patients with carcinoma and 2 with diverticulitis, who suffered acute interruption of intestinal humoral continuity.

The recognition that acute intestinal obstruction is present is far easier many times than is the discovery of the etiological agent or the choice of a therapeutic procedure. A careful history, a thorough physical examination, and meticulous, repeated observation of the patient, are essential. Some help will be obtained from the age of the patient, for as has been previously stated, certain types of pathological lesions are associated with various age groups. Thorough palpation of the

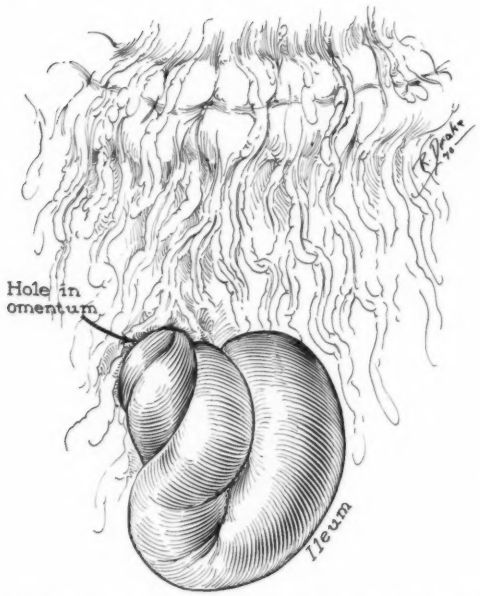

Fig. 2. An internal hernia the result of a rent in the omentum.

external orifices at which hernia may be present will disclose the cause in the majority of cases, whereas a history of a previous abdominal operation will suggest the possibility of another group.

The type, severity, and site of pain and the localization of borborygmi are further factors that merit detailed consideration. Abdominal distention may or may not be present. Blood may be found in the vomitus or the stool, so that conditions commonly associated with these particular findings should be considered first. Simple roentgenograms of the abdominal cavity, repeated if necessary, are valuable aids in localization. Gas is rarely seen in the small bowel in adults unless there is interruption of the intestinal continuity proximal to a patent ileocecal sphincter. Visualization of coils of the small intestine should indicate obstruction in these cases. If a distended "horse-shoe" colon is seen, stasis in that particular part of the bowel has occurred. Above all else, the presence or absence of a strangulating lesion must be primarily demonstrated as the mortality

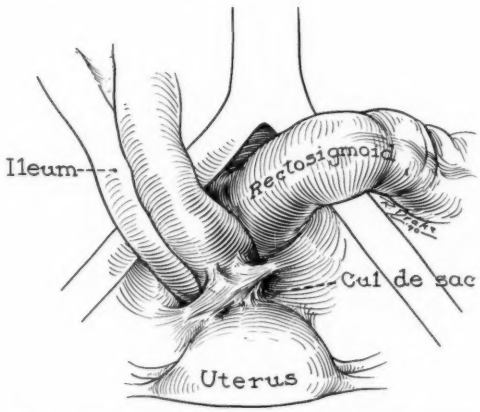

Fig. 3. A loop of terminal ileum adherent in cul-de-sac.

rate rises sharply if patients who have a necrotic bowel are improperly treated. A rapid onset of symptoms with severe pain, vomiting and shock associated with peritoneal irritation, marked abdominal tenderness, splinting, and increase in the number of leucocytes in the blood must suggest a strangulation of the bowel. The ratio of duration of the obstructive process to the mortality rate is a simple one: the longer the obstructive process lasts the greater the mortality.

Having made a careful analysis of the picture presented by the individual patient, the surgeon must plan his treatment accordingly. Simple mechanical obstructions of the small intestine early in the postoperative period, in cases in which the possibility of strangulating lesions can be eliminated, respond well to decompression of the bowel by use of the Wangensteen method. Such a statement is not universally true for obstructions of the small intestine caused by bands and adhesions in the late postoperative period. An analysis of the results in that particular group reveals a high incidence of strangulation. Signs indicative of this condition must be watched for and, if not present, conservative treatment may be employed. Colonic obstruction must be considered a strict contraindication to the use of suction drainage. It is true that in some cases with a patent ileocecal fold, decompression may be effective, but the experience of seeing a few ruptured

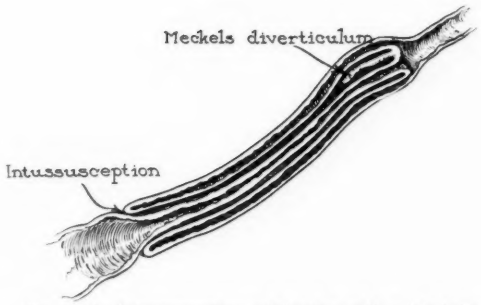

Fig. 4. An intussusception originating with a Meckel's diverticulum.

cecums will quickly influence the mind of the surgeon. Cecostomy or colostomy is the procedure of choice and does not carry an elevated risk in comparison with "blind" intubation.

Orr has estimated that approximately 7,300 to 8,000 cubic centimeters of fluid are secreted into the upper portion of the intestinal tract daily. Repeated vomiting in obstructive cases will lead to dehydration, depletion of blood chlorides, and alkalosis. Sufficient fluid must be given parenterally to insure an output of 800 to 1000 cubic centimeters of urine daily. Frequent estimations of the blood chlorides, carbon-dioxide combining power, and urea are necessities in the rational treatment of such patients.

When operation is indicated, the most conservative procedure possible under the existing circumstances should be employed, after the patient has been prepared for the operation. The preparatory period must vary with the individual patient and may at times be quite short. Favorable signs attendant on the release of the obstructing agent in strangulated loops are a return of the normal color to the bowel, pulsations in the vessels, and peristalsis on stimulation. Warm packs are placed around the liberated loop and 100 per cent oxygen is administered to the patient. A comparatively rapid accurate estimation of viability of the bowel can thus be made. When resection is necessary, the loop should be exteriorized and the continuity of the bowel restored later when the patient is in better condition. Primary resection, with closure of the bowel and side-to-side anastomosis is too

Fig. 5. Acute intestinal obstruction from a strangulating band.

hazardous a procedure unless a small lesion high in the intestine is present.

Useful postoperative adjuncts in therapy are blood transfusions and the use of 100 per cent oxygen employing the B.L.B. inhalation apparatus (1). Loss of blood into the lumen in the case of strangulating lesions of the bowel may be considerable. Anoxemia of the patient and particularly of the bowel will be combated effectively by the use of oxygen.

Any consideration of treatment should include prophylactic measures designed to reduce the incidence of acute intestinal obstruction. Review of the cases in this series has demonstrated two important facts. External hernias account for a large majority of the cases and many of these patients are in the older age groups. Acceptance of old age as an excuse for employing prophylactic surgery for dangerous diseases is now gradually being withdrawn. As Clagett and Waugh have reported, an approximate mortality rate of 0.33 per cent was attendant on a series of almost 600 uncomplicated inguinal hernias repaired at the clinic during 1937 and 1938. The repair of a strangulated hernia carries with it many times such a risk. One should unhesitatingly recommend repair of all hernias at any time to forestall strangulation provided the patient is in a sufficiently good state of health.

The mortality from acute intestinal obstruction is high and will remain so until

Fig. 6. Operative findings in volvulus of the small intestine.

educational measures can correct the situation. A correlation between the duration of obstruction or strangulation and the mortality rate is definite. This fact is strikingly confirmed in the present series in which the combined mortality in 136 patients was 22 per cent. Investigation of the patients who succumbed revealed that about half of them had been ill for more than 48 hours before coming to operation and an additional 3 had been ill about 48 hours. If it had been possible to have had most of these patients in the hospital earlier, the mortality rate might have been reduced substantially. The following report of cases is appended to illustrate the difficulties which may be encountered in the diagnosis and treatment of acute intestinal obstruction.

REPORT OF CASES

CASE 1. A white woman, 27 years of age, who had had extensive pelvic surgery here about 7 months previously, was well until 2 weeks prior to admission, when she began having moderate epigastric distress, mainly after meals. Five days before her admission, a severe colicky pain developed just below the xiphoid process; this pain projected toward the back between the scapulæ. Frequent vomiting but no evidence of icterus was present. Normal appearing bowel movements had taken place twice. Roentgenograms made elsewhere had disclosed a "stone at the mouth of the cystic duct."

On admission, the abdomen was slightly distended. Rigidity was lacking, but mild diffuse tenderness was noted. Leucocytes numbered 14,900 per cubic millimeter; 81 per cent were polymorphonuclear leucocytes. A roentgenogram of the abdomen revealed gaseous distention of the small bowel, especially of the jejunum. A diagnosis of cholecystic disease with calculus was entertained but intestinal obstruction could not be excluded and conservative measures were instituted. No great change in the condition of the patient resulted and exploration for the presence of obstruction of the small intestine was undertaken.

On opening the peritoneal cavity, considerable serosanguineous fluid was present and the entire small intestine was dilated to 4 or 5 times normal size. A loop of ileum, about 6 inches (15 cm.) long, quite close to the ileocecal valve had become twisted on itself, and had been occluded by a strangulating adhesive band (Fig. 5). Perforation of the proximal limb of the occluded loop occurred while the structure was being gently freed. Resection of the loop would have necessitated sacrificing part of the right colon. Therefore, the necrotic portion was trimmed away and the opening in the ileum was enlarged longitudinally. The rent was closed transversely, and an enterostomy was performed at a point 8 to 10 inches (20.32 to 25.40 cm.) proximal to the region. A blood transfusion, Wangensteen suction, and an oxygen tent contributed greatly to a smooth convalescence.

CASE 2. The following case has been reported elsewhere by one of us (Stalker). A white man, aged 42 years, registered at the clinic and complained of abdominal pain, nausea, and vomiting. Treatment had been administered elsewhere for 4 days and on registration here a constant ache was present in the region of the umbilicus with tenderness in the right lower abdominal quadrant. Frequent vomiting of large quantities of bile-colored fluid occurred. Defecation had not occurred since the onset of pain, but daily high enemas were expelled with gas.

The patient was critically ill, extremely dehydrated, and in a toxemic condition. The abdomen was distended moderately, was tense and felt doughy. Generalized tenderness, most severe to the right and below the umbilicus, was present. A few distended loops of intestine could be palpated, marked abdominal succussion sounds were noted, and some audible peristalsis was present. It was obvious that the patient was too ill for an immediate surgical procedure. A blood transfusion, the intravenous administration of several liters of saline solution, and continuous duodenal suction were instituted. Improvement in the general condition

was noted, but the abdominal findings remained about the same. A leucopenia was present, the number of leucocytes being 3,300 per cubic millimeter. Gaseous distention of several loops of small intestine was revealed by roentgenological examination.

Although the patient was critically ill, it was felt that maximal benefit had been obtained by this preoperative preparation, and consequently surgical intervention was advised. Approximately 2 liters of amber-colored serous fluid were released when the peritoneal cavity was opened. The mesentery of the small intestine was found twisted on itself about three and a half times in a counterclockwise direction; 95 per cent of the small intestine was involved (Fig. 6). Marked discoloration and distention of the affected small bowel was present. Untwisting of the mesentery resulted immediately in a return of normal color to the intestine and passage of some gas distally. No definite cause for the volvulus was found.

After operation, blood transfusion, Wangensteen suction, and concentrated oxygen therapy contributed materially to a smooth convalescence. The patient was dismissed from the hospital on the fourteenth day.

CASE 3. A white woman, aged 55 years, stated on registration that for 3 days she had suffered from generalized cramp-like abdominal pains. Vomiting of bile colored fluid was frequent and she had not had a bowel movement or passed flatus for 2 days. Dyspepsia, the result of gall-bladder disease, had been present for many years and 6 years before admission patient had suffered from acute cholecystitis.

Physical findings were limited to the abdomen. Tenderness and rigidity were not present and visible peristalsis was not observed. Borborygmi were heard during the attacks of crampy pain.

The leucocytes numbered 24,800 per cubic millimeter; 90 per cent were polymorphonuclear leucocytes. The constituents of the blood in milligrams per 100 cubic centimeters were: urea, 80; chlorides, 462; and the carbon-dioxide combining power, 49.5. A simple roentgenogram of the abdomen revealed a short length of bowel in the upper portion of the abdomen filled with gas.

At operation, the upper part of the jejunum was found dilated to about two or three times its normal size and a gall stone was causing obstruction about 48 inches (120 cm.) distal to the ligament of Treitz (Fig. 7). The duodenum and gall bladder were freed and a cholecystduodenal fistula visualized. A gall stone measuring 4 by 2 inches (10 by 5 cm.) was removed from the jejunum and the opening in the duodenum was closed as a pyloroplasty. Cholecystostomy completed the operation. Her postoperative convalescence was smooth and was aided by the usual procedures.

The mortality resulting from acute interruption of intestinal humoral continuity is excessive as is evidenced by this and other reports. Chief among the causes of the death

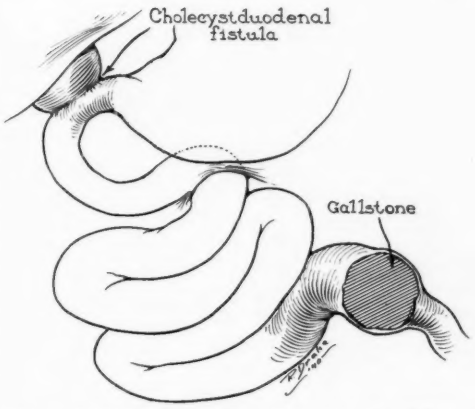

Fig. 7. Acute ileus caused by gall stone in the jejunum.

rate is the marked delay in recognizing and treating strangulating lesions. This fact is especially true in regard to the treatment of obstructions caused by bands and adhesions in the late postoperative period. Recognition and employment of the dictates advocated by Wangensteen and others should materially aid in the reduction of the excessive mortality rate. The prophylactic repair of hernias in suitable cases will reduce not only the incidence of obstruction but also the resultant mortality rate. The use of 100 per cent oxygen will be found valuable not only at the time of operation in making a decision in regard to the viability of bowel, but it also will prove helpful in the postoperative care of such patients.

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REACTION OF BONE TO MULTIPLE METALLIC IMPLANTS

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RECENT papers by Venable and by Venable and Stuck have created new interest in the problem of finding metallic prosthetic material for bone repair. They have found that vitallium, an alloy of chromium, cobalt, and molybdenum is tolerated better than other metals or alloys and have ascribed this to its resistance to corrosion by body fluids. They have shown also that this resistance to corrosion is manifested by its non-reactance to electrolytic influences. Zeinert observed differences in electrical potentials between dissimilar metals and concluded that only a single metal should be used and that all metal should be removed as soon as possible. Hawley and Padula expressed the belief, based on clinical experience, that there was little choice between stainless steel and vitallium. Crowell has reviewed the status of metallic devices used in bone fixation, particularly those made of vitallium and stainless steel. He emphasized the importance of resistance to corrosion and physical strength of such devices, but the question of the part played by electrolysis was not settled.

In 1924, Zierold made an intensive study of the reaction of bone to a number of pure metals and of alloys. He used 63 dogs and placed metallic implants in ribs, tibias, and femurs. Gold, aluminium, and stellite (an alloy consisting mainly of cobalt, chromium, and tungsten) were well tolerated and became encapsulated without hindering reparative processes. Silver and lead were almost as good but evoked a slightly greater connective tissue response.

Verbrugge has reported the results obtained from the use of magnesium and Dow metal (92 per cent magnesium, about 8 per cent aluminium and a small amount of manganese) both clinically and in experimental studies in dog and rabbit. These materials were absorbed but caused considerable reaction, and it was concluded that small nails of such materials could be used but not plates. McBride used with success in 20 human cases a similar alloy which contained 95.7 per cent magnesium.

Our work differs from that of Zierold in that multiple metallic implants are used in the same bone with the idea that electrolytic action might be exaggerated if the part it plays be of major importance. We have included two metals, titanium and manganese, which we believe have not been studied previously.

Experimental. Holes about 1.5 millimeter in diameter were drilled in the shaft of the femur of cats with a dental drill, and pegs of the metals to be tested fitted tightly into them. Aseptic precautions were used and the wounds

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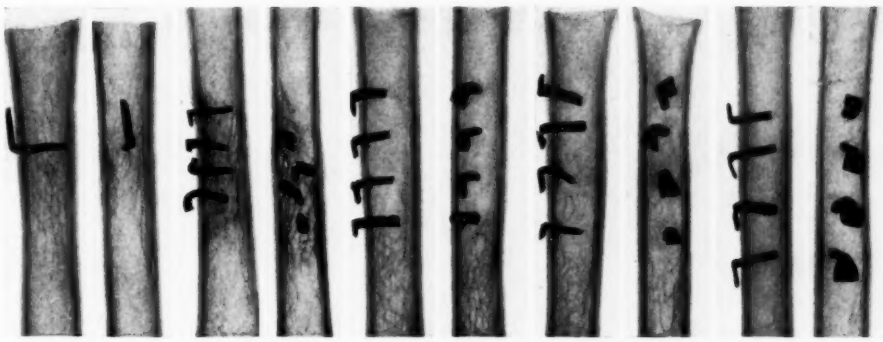
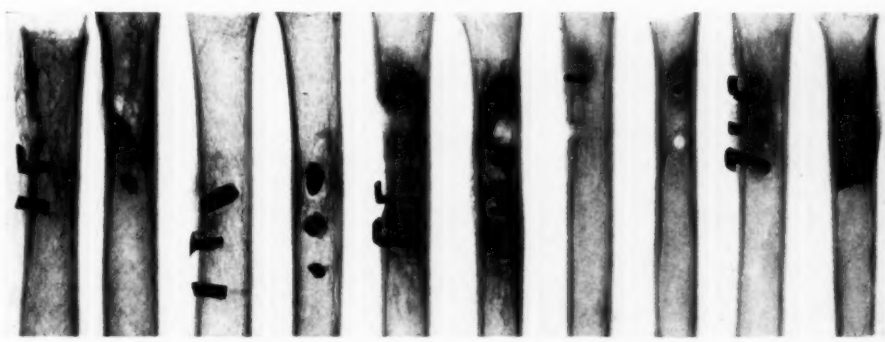


1. 225 d. St S only | 2. 232 d. Zn,Sn,Pb,Cd | 3. 218 d. Zn,St S,Pb,Fe | 4. 228 d. Pb,Fe,Sn,Zn | 5. 17 d. Zn,Sn,Pb,Cd

6. 214 d. Mg only | 7. 266 d. Sn,Pb,Cd,Al | 8. 259 d. Al,Cu,Pb,St S | 9. 8 d. Cu,Fe,Pb,St S | 10. 224 d. Mg,Mn,Ti,Vit



11. 224 d. Mg,Mn,Ti,Vit | 12. 31 d. Cu,Mn,Ti,Vit | 13. 224 d. Al,Cd,Cu,Fe | 14. 210 d. Mn,Mn,hole | 15. 203 d. Hole,Cu,Mn,Pb

Figs. 1, 2 and 3. Roentgenographic positive prints of femurs of cats into which implants of various metals were made. The legend below the figures gives the figure number, which corresponds to the cat number in Table II, the survival time in days and the metals used. Read from top to bottom in identifying the metals in the bones. Each pair represents the same bone, photographed to give side and end views of the implants.

TABLE I.—ELECTRICAL POTENTIALS OBTAINED FROM METALS IN CAT FEMURS WITH COPPER, EITHER IN THE BONE OR ADJACENT MUSCLE, USED AS A ZERO POINT OF REFERENCE. HYDROGEN IS PLACED WHERE IT WOULD OCCUR IN THE ELECTROMOTIVE FORCE SERIES

Metal	Potential volts
Cadmium and manganese	+0.50
Aluminium	.45
Tin	.30
Lead	.25
(Hydrogen)	
Titanium	.05
Copper, vitallium, and stainless steel	.00
Platinum (in muscle)	−0.30

were closed in layers with sutures of fine silk. A survival period, which varied from 203 and 259 days, was allowed in 12 of the 15 cats used. Three died 8, 17, and 31 days, respectively after operation from respiratory infection. Readings of the voltage between the different metals were taken with a potentiometer in 4 of the animals, each of which had 4 implants in each femur. The readings were taken at the end of the experimental period on the anesthetized animal.

The following metals were used, and the number after each indicates how many implants were made: aluminum, 3; cadmium, 4; copper, 5; iron (as soft steel), 4; magnesium, 3; manganese, 6; lead, 8; tin, 4; titanium, 3; zinc, 4; stainless steel,[1] 4; and vitallium, 3. Four different metals were usually implanted in one femur.

Results. Electrical potentials varied from zero to over 0.40 volts (the limit of the potentiometer used). Such potentials obtained from a pair of different metals with living tissue as the electrolyte tended to be unstable but duplicate readings agreed sufficiently well to permit the computation of the data in Table I. Copper, vitallium, and stainless steel have been given the zero position arbitrarily. This was done because a copper electrode in the muscle was used to check against other metals in the bone. Copper in muscle to copper in bone gave readings from 0 to 0.02 volts. The potentials follow the same order as that of the electromotive force series of elements with the exception of aluminium, which should have been positive to cadmium. In view of its reaction with the bone (contrary to Zierold's findings) the aluminium sample may have been impure.

Roentgenograms were made of the cleaned bones and are illustrated in Figures 1 to 15. Table II gives a condensed protocol of the observations on the bones correlated with the roentgenographic shadows.

[1]Iron, chromium, nickel, manganese alloy which contains small amounts of silicon, sulphur, phosphorus, and carbon.

EVALUATION

Electrical potentials are not an infallible guide concerning the amount of reaction between bone and metal. This should not be interpreted to disagree with the work of Venable and co-workers since they are dealing with current rather than potential. It does suggest, however, that electrolysis is an accompaniment of unfavorable bone reaction rather than the direct cause of it. Under our experimental conditions where electrolytic action should have been favored by adjacent dissimilar metals, each metal retained characteristic individuality of reaction. In interaction between bone and metal, chemical reactivity is usually correlated with large positive potentials of the metal with relation to hydrogen in the electromotive series. Examples are manganese, magnesium, and aluminium. Cadmium, however, seems to be an exception in the strongly positive group, since two of three implants showed little reaction to this metal. Metals negative to hydrogen might be expected to be non-reactive, but copper gives an unfavorable reaction which is due to the toxicity of its dissolution products. The individuality of a given metal may be illustrated by other examples. Manganese reacted as vigorously when implanted alone (Cat 14) as it did in company with other metals. The inert alloys and titanium remained inert in the presence of reactive metals (Cats 3, 8, 10, 11, and 12).

The response of bone to titanium was as good, if not better, than that to the noncorrosive alloys, in that there was more tendency for the bone to fuse with it. It possesses the advantage of being an element and hence free from the theoretical objections to alloys, which were discussed in Crowell's report. If

TABLE II.—REACTIONS OF FEMURS OF CATS TO MULTIPLE IMPLANTS OF VARIOUS METALS

Cat No. and sex	Survival: days	Metals used	Reaction
1 M	225	Stainless steel	No reaction
2 M	232	Zn,Sn,Pb,Cd	A cystic cavity (0.5 by 1 by 2 cm.) covered the 4 pins
3 M	218	Zn,St S,Pb,Fe	Slight erosion about Zn, others are tight in the bone
4 M	228	Pb,Fe,Sn,Zn	Some cortical thickening about all except Fe. It shows slight thinning. Sn and Zn show a trace of erosion between metal and bone
5 F	17	Zn,Sn,Pb,Cd	Subcortical shadows about Zn and Pb. Time was too short for much bone reaction.
6 M	214	Mg only	Absorbed: bone is smooth
7 F	266	Sn,Pb,Cd,Al	Erosion immediately about Al with increased density around the eroded zone. Other metals show little effects.
8 F	259	Al,Cu,Pb,St S	Both Al and Cu are similar to 7. Pb and stainless steel are practically negative
9 M	8	Cu,Fe,Pb,St S	Time was too short for reaction
10 F	224	Mg,Mn,Ti,Vit	Mg nearly absorbed; erosion about Mn with small crater. Ti and Vit negative
11 F	224	Mg,Mn,Ti,Vit	A fragment of Mg remains. The Mn was loose, dropped out, and there is crater and new bone formation around the site. Ti is partly covered by new bone, which has extended also around the vitallium
12 F	31	Cu,Mn,Ti,Vit	The Cu pin came out of the bone soon after operation and was found embedded in connective tissue. Mn is loose and there is crater formation and much callus around it. Ti and vitallium are negative
13 F	224	Al,Cd,Cu,Fe	Probably infected. Al and Cd have sloughed into a cystic cavity. Cu and Fe are loose. Bone cortex and medulla are very dense
14 F	210	Mn,Mn,hole	One implant has been partly covered by callus, the other remained loose in a crater and dropped out. There is increased density around the eroded area. The hole has healed
15 F	203	Hole,Cu,Mn,Pb	The hole has healed. There is much callus heaped up around the Mn and increased density around it and the Cu. The callus has grown into contact with the Pb but avoided the Cu

metallurgical developments of the future make it possible to work it into suitable shapes, it has the strength and hardness necessary for proper support. More experimental work is needed to prove it equal or superior to the noncorrosive alloys as a prosthetic material.

TABLE III.—ORBITAL ELECTRONS OF ELEMENTS WHICH CAN NORMALLY OR ABNORMALLY PARTICIPATE IN BONE METABOLISM

Element	Shell	K	L	M	N	O	P	Q
	Orbit	1s	2s 2p	3s 3p 3d	4s 4p 4d 4f	5s5d5p	6s6p6d	7s
Be		2	2					
Mg		2	2 6	2				
Ca		2	2 6	2 6 —	2			
Ti (?)		2	2 6	2 6 2	2			
Mn		2	2 6	2 6 5	2			
Fe		2	2 6	2 6 6	2			
Sr		2	2 6	2 6 10	2 6 — —	2		
Pb		2	2 6	2 6 10	2 6 10 14	2 6 10	2 2	
Ra		2	2 6	2 6 10	2 6 10 14	2 6 10	2 6 —	2

Data taken from the *Handbook of Chemistry and Physics;* Chemical Rubber Publishing Company, 1939

Lead, although positive to hydrogen, was well tolerated and this fact is probably correlated with the well known tendency for lead salts which have been absorbed in the body to be deposited in the bones. The close relationship between bone metabolism and certain metallic salts has been cited by Blumberg, Shelling, and Jackson, in a study of manganese rickets in rats. Salts of strontium, beryllium, magnesium, thallium, iron, aluminium, and lead are included in their list and specific references to experiments given. In our series, manganese gave a very marked reaction by causing a proliferation of new bone on the surface of the cortex for several millimeters around the implant, but resorption in the immediate vicinity of the metal.

There seems to be a correlation between the chemical properties of a metal (or its salt) to its reaction with bone. This phenomenon can be illustrated further by Table III wherein it is seen that there is much similarity in the configuration of electrons in the outer shells of the elements involved. The most closely related of the metals are magnesium, calcium, strontium, and radium. Each of these has 2 outer electrons in an s-orbit preceded by 6 in a p-orbit. Others not quite so closely related are beryllium, titanium, manganese, and iron, which also have 2 outer electrons in an s-orbit but are not preceded directly by a p-orbit. Lead, however, is aberrant by having two outer electrons in a p-orbit.

These relationships between metallic salts and bone metabolism, and similarities of atomic structure existing among such metals suggest that any relationship between metal and living bone is likely to be more firmly grounded on a chemical, than on an electrolytic, basis. Electrolysis, as manifested by an actual flow of current, should serve as a valuable guide regarding the solubility of a metal.

SUMMARY AND CONCLUSIONS

1. Implants of dissimilar metals into the same bone (cat femur) still showed differences in electrical potential after 7 months.

2. Such potentials were not closely correlated with bone reaction except in the case of the more soluble metals which were strongly positive in the electromotive series.

3. Two pure metals, manganese and titanium, were included in the study, and we believe that their reactions in bone has not been observed previously. Manganese was highly reactive and promoted much callus formation. Titanium was fully as well tolerated as vitallium and stainless steel, perhaps better in that the bone had a tendency to grow into contact with it.

4. Some theoretical reasons are given for believing that the response of bone to metal is based on chemical rather than electrical phenomena.

NOTE.—The vitallium used was furnished gratuitously by the Austenal Laboratories, and the stainless steel by V. Mueller & Co.

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THE IVY BLEEDING TIME, SERUM VOLUME INDEX AND PROTHROMBIN CONTENT OF BLOOD IN ESTIMATING BLEEDING TENDENCY IN JAUNDICE

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IT is now well recognized that prothrombin deficiency is an important cause of hemorrhage. It has been adequately demonstrated that this deficiency may occur in the newborn due to a lack of vitamin K (3, 8, 10). In patients with biliary obstruction or fistula, bleeding is known to occur because of a deficient absorption of vitamin K, due in large measure to the absence of bile salts in the intestine. In other conditions where deficient intestinal absorption is a factor, a prothrombin deficiency may appear. Clark, Dixon, Butt and Snell have demonstrated it in intestinal obstruction, gastrocolic and other intestinal fistulas, ulcerative colitis, multiple polyposis, sprue, and in postoperative gastric retention. Bleeding occurred in some of these conditions. Finally, a deficiency of prothrombin has been shown to occur in various types of hepatic dysfunction (8, 9) due to an inability of the liver to form prothrombin.

These relatively recent additions to our knowledge concerning prothrombin deficiency have awakened a new interest in and made thorough the study of patients who might bleed after operation. Especially in the preoperative and postoperative management of patients with jaundice or biliary fistula has it become imperative to know the status of the bleeding tendency. On it depends the time chosen for operation, the necessity for transfusion, or the success or failure of vitamin K and bile salt therapy.

In estimating the tendency to bleed, the most valuable information is the prothrombin time or the prothrombin percentage, which is usually obtained by the method of Quick (7). This method provides a direct means of measuring the rate of coagulation in oxalated plasma by a system wherein there is an excess of thromboplastin and an approximately optimal content of calcium. The rate of coagulation is dependent, therefore, upon the prothrombin content of the plasma. The determination of prothrombin deficiency by this method is not difficult in large or well equipped laboratories by those who are skilled in laboratory methods. However, several reagents and a considerable equipment are necessary for the test; the most difficult to obtain is the thromboplastin solution. This requires maceration of rabbit's brain and several extractions with acetone. The resultant granular powder is unstable; it must be preserved in a refrigerator and even then it is found to retain its full activity for only a week. Quick advises that its activity should be checked against a normal plasma in estimations of prothrombin content of a questionable blood.

We decided to determine the value of two more simple clinical tests for determining the bleeding tendency in several patients with jaundice or biliary fistula. These tests were made on the same blood and at the same time that the prothrombin estimations were made, so that the results were comparable in every respect. We hoped the results obtained might be helpful to those in smaller hospitals where prothrombin estimations are not made routinely, or even in larger hospitals where it is desirable to follow the bleeding tendency from day to day. Furthermore, the tests can be rapidly performed at the bedside, with a minimum of apparatus and without the necessity of any skilled or trained personnel. If the determination of the tendency to hemorrhage can be estimated fairly accurately by clinical tests, it would seem practical to substitute them for laboratory procedures in many instances.

The two tests run simultaneously with the prothrombin determinations in this study were the Ivy bleeding time (6) and the serum vol-

From the Surgical Service of L. K. Ferguson and the Laboratories of the Philadelphia General Hospital.

TABLE I.—DETERMINATIONS

Prothrombin percentage	Ivy bleeding time—minutes	Serum volume index
*33	*5.0	*0.5
6	5.5	0.4
16	20.0	0.2
8	3.5	0.67
16	4.5	0.69
16	4.5	0.66
30	2.5	0.48
*50	*20.0	*0.5
13	6.5	0.66
*30	*10.0	*0.76
27	5.0	0.66

ume index of Boyce (1). Neither test makes a quantitative estimation of the prothrombin content of blood, but their value lies in the fact that indirectly their results depend upon it.

The Ivy bleeding test consists in observing the duration of bleeding, by blotting away the drops of blood from a small puncture wound in the skin of the forearm, while the venous return is temporarily obstructed below a sphygmomanometer cuff inflated to 40 millimeters of mercury. At the time Ivy proposed his test (1935) less was known about the relation of prothrombin deficiency to bleeding, but he recognized that the duration of bleeding from a puncture wound was a factor not only of the clotting function of the blood, but also of the contraction and retraction of the injured capillaries. He proposed to eliminate this factor of capillary tonus by increasing the pressure in capillaries and arterioles, using a blood pressure cuff to obstruct the venous return. The duration of bleeding would then be almost entirely an index of the clotting function of the blood, i.e., an index of prothrombin content. By Ivy's standard, a bleeding time of more than 240 seconds (4 minutes) was considered as showing a tendency to bleed.

The serum volume test of Boyce and McFetridge is performed by collecting an arbitrary amount of blood, usually 3 cubic centimeters, in a graduated tube, allowing it to stand at room temperature for 4 hours. The clot is then removed and studied for firmness and retractility. An observation is made of the amount of serum remaining in the tube. In normal individuals this serum volume was found to equal 50 per cent of the original blood volume. In patients who had a tendency to bleed, the serum volume was found to be much less than this. A serum volume index was proposed, and was obtained by dividing the amount of serum left in the tube after removal of the clot by one-half the original blood volume. This index was one in normal individuals.

In performing this test, it is essential to have at hand a red blood count because, if the volume of corpuscles is reduced, the resulting serum volume will be increased (2). Unless a correction is made, the serum volume index will appear higher than it really is. Subtracting the red blood count of the blood tested from 5,000,000, the normal blood count, the resulting figure is divided by 5,000,000 to give the percentage deficiency of red cells. This figure is then multiplied by one-half the volume of the blood drawn to give the volume to be subtracted from the serum volume as read. The serum volume index is then calculated as usual, the corrected figure being used.

Indices below 1.0 are considered as progressively indicative of a hemorrhagic tendency. The highest serum volume index at which the authors found bleeding was 0.71; the lowest at which hemorrhage did not occur was 0.78. It would seem then that the lower limit of safety is between 0.7 and 0.8. Boyce and McFetridge state, however, that they are unwilling to operate when the index is below 0.8.

This test, like the Ivy bleeding test, is apparently an indirect measurement of prothrombin deficiency because the clot in patients with a decreased prothrombin content of the blood is larger, softer, and more friable than the normal. Therefore, the volume of serum left after removal of such a clot is less than normal.

In following the course of one patient with a complete biliary fistula, simultaneous determinations of the Ivy bleeding time and the serum volume index were made along with the determination of blood prothrombin levels by the method of Quick. The results showed a rather close parallelism. The findings in this case have been reported in a previous publication (5).

Our interest in further observing the results of these three tests applied to other individuals has led to the present study. From the results of studies of 27 jaundiced patients, in whom jaundice was due to various causes, we believe that there is sufficient correlation to warrant confidence in the use of the two simpler tests as adjuncts to, or substitutes for,

prothrombin studies, or in places where laboratory facilities for prothrombin determination are not available.

We have divided our cases into two groups. One consists of patients showing a clinical bleeding tendency or a blood prothrombin level of 30 per cent or less. The other is made up of those patients having no clinical tendency to bleed or a blood prothrombin level of more than 30 per cent. Thirty per cent was selected arbitrarily as a level at which danger of bleeding due to prothrombin lack was imminent.

Table I includes 9 determinations in which the prothrombin percentage was 30 or less. In each of these patients, either the Ivy bleeding time or the serum volume index or both indicated a definite bleeding tendency. Three cases are marked by asterisks. In 2 of these the prothrombin percentage was greater than 30: 33 and 50 per cent; in both, a definite hemorrhagic tendency was suggested by the Ivy bleeding test, the serum volume index, and by clinical evidence of bleeding. In the third case, the serum volume index was 0.76, a figure not definitely indicating a bleeding tendency, though here the Ivy bleeding time was 10 minutes.

Table II includes those cases in which the prothrombin percentage was above 30. In none of these cases was there clinical evidence of bleeding. Seven patients showed a serum volume index between 0.7 and 0.8. Four cases are marked by asterisks. In 3 of these, the Ivy bleeding time indicated a bleeding tendency and, in the other, the serum volume index was reduced to a definitely critical level. However, in no case did both tests indicate a definite hemorrhagic tendency, although in 2 with the Ivy bleeding time prolonged the serum volume index was between 0.7 and 0.8.

In our series, therefore, either one or both of the two simple tests used in combination showed the tendency to hemorrhage in cases in which it was indicated by determination of the blood prothrombin level. In 2 cases both of them indicated the hemorrhagic tendency in agreement with the clinical evidence, while the prothrombin percentage did not. In 4 cases, however, 1 or the other of the simpler tests indicated a hemorrhagic tendency when there was no other evidence that it existed.

TABLE II.—PROTHROMBIN PERCENTAGE ABOVE 30

Prothrombin percentage	Ivy bleeding time—minutes	Serum volume index
65	3.5	.72
*90	*4.5	*.77
43	2.8	.72
46	2.0	.87
54	2.5	.93
58	2.5	.93
*90	*2.0	*.52
100	2.5	.74
35	2.5	.73
100	2.5	.94
100	2.0	1.0
70	2.0	.94
*50	*6.0	*.78
*40	*5.0	*.88
48	2.5	1.0
43	2.5	.78

SUMMARY

We have compared three methods for determining the bleeding tendency in patients with jaundice or biliary fistula. The method of Quick for determining blood prothrombin percentage requires certain laboratory facilities and material as well as skilled personnel, not always easy to obtain. The two other tests, which are simple bedside procedures requiring no specially prepared reagents and no elaborate equipment, compared favorably with the Quick method.

We believe that their correlation with the blood prothrombin level is close enough and their indication of a tendency to bleed accurate enough to give them a definite value in the study of such patients, either as confirmatory procedures where prothrombin determinations are obtainable or alone where elaborate laboratory facilities do not exist.

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PERFORATED PEPTIC ULCER

A More Accurate Method of Roentgen Diagnosis

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THE purpose of this paper is to show the value of roentgen examination in the left lateral decubitus position in ascertaining the presence of air under the diaphragm. Since the earliest notations by the German writers, Popper and Weiland, concerning the "radiologic phenomenon" associated with perforated viscera, namely, the finding of air beneath the diaphragm, numerous writers have concentrated their efforts in establishing the value of x-ray examination in such cases. That they have succeeded is attested by the fact that in cases of questionable perforation, roentgen examination is now used universally as a diagnostic procedure.

Reports of atypical cases of perforation, in which the diagnosis was made only by x-ray, are numerous. Most writers have found, however, that approximately 20 to 25 per cent of cases of perforated viscera do not show air beneath the diaphragm when the examination is made with the patient in the upright position. Petren, in a series of cases reported in 1937, did not find gas in 32 per cent. With careful examination, sometimes serial, in the left lateral decubitus position, this percentage has been reduced to 11 per cent in a series of 68 cases seen at the San Francisco Hospital in the past 5 years.

Examination of the patient in the left lateral decubitus position is not a widely known or accepted procedure. The majority of examinations for demonstration of air under the diaphragm are still made with the patient in the upright position only.

The reasons for the universal reliance upon the upright position seem to be: (1) The "weight of custom"—"the upright position has always been used; therefore, it must be the best projection." (2) Only a few series with examinations in both positions have been reported. (3) Conflicting reports in the literature as to the relative values of the left lateral decubitus position.

As late as 1937, we find this statement: "The one absolute essential [to the demonstration of pneumoperitoneum] is that the patient be put in the upright position during the x-ray exposure" (7). Another article published in 1938 states: "Roentgen examination in the left lateral decubitus position is useful when the patient cannot be placed upright. However, if pneumoperitoneum is observed at all on the x-ray film, it will be seen between the right dome of the diaphragm and the liver in 90 per cent of the cases" (8).

These statements contrast with those of Vaughan and Singer who, in 1933, in conclusion to a study of 97 cases of perforated ulcers, stated that "the optimum position [to demonstrate free peritoneal air] is with the patient lying on his left side. It is unnecessary to place the patient in a sitting or other position." Clarkson and Barker, in a subsequent article, corroborated this point. Finsterbusch and Gross in *Acta Radiologica*, 1932, likewise stated that they "prefer the left lateral decubitus position because, in that position, very small amounts of gas can be seen more readily in contrast with the dense shadow of the liver, the diaphragm, and the lateral wall of the abdomen."

Darbois and Sobel in 1930, after performing a number of experiments on cadavers by forcing air into the stomach and out through perforations in the duodenum, made the statement that air passed most freely into the peritoneal cavity when the cadaver was placed in the left lateral decubitus position.

DEFINITION AND TECHNIQUE

By the term "left lateral decubitus position" is meant a posterior-anterior examination with the patient lying on his left side with his right

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side up (Fig. 1). The x-ray is directed horizontally to the film placed on the opposite side of the patient. The film is placed to include the liver area and lower right lung field.

RATIONALE—ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

What is the rationale of the left lateral decubitus position? Our query first brings us to a consideration of the diaphragm and its relationship to the liver. Quoting from Gray's *Anatomy*: "Skiagraphy shows that the height of the diaphragm in the thorax varies considerably with the position of the body. When the body is horizontal and the patient on his side, the two halves of the diaphragm do not behave alike. The uppermost half sinks to a level lower even than when the patient sits, and moves little with respiration; the lower half rises higher in the thorax than it does when the patient is supine, and its respiratory excursions are much increased." Thus there is, in the left lateral decubitus position, a pump-like action; the lower left half of the diaphragm, by its vigorous movements, forces any free intraperitoneal air upward into the space between the relatively stationary right leaf of the diaphragm and the liver.

The next structures with which we are concerned are the stomach and duodenum. We are especially interested in the pyloric region, as the great majority of perforating ulcers occur here on the anterior surface. As is well known, ulcers pointing posteriorly penetrate, but do not easily perforate because of the proximity of the tissues behind them.

Roughly, the gross outline of the stomach can be considered to resemble the letter J (Fig. 2a). The hook of the J, extending from the left to the right of the midline, is made up of the pyloric antrum and duodenal bulb. It is readily seen that if the patient were in an upright position, even a relatively small amount of fluid would fill the hook of the J, the antrum and cap, and block any air from escaping from a hypothetical hole in this region (the site of rupture in 80 to 90 per cent of all cases). Also in this position fluid escapes more easily, increasing the possibility of peritonitis or subphrenic abscess. On the other hand, if the patient were lying on his left side, the contents of the stomach would gravitate to the cardia and fundus, and air could readily escape through the rent in the pylorus or duodenum (Fig. 2b). Clarkson and Barker report in 1935: "In order to minimize as far as practicable the escape of fluid and solid matter, a patient suspected of having a perforated peptic ulcer should be kept constantly on his left side with the upper half of the body elevated." Vaughan and Singer elaborate on this point in cases of suspected small perforations. They state: "In a number of *forme fruste* perforations, where the clinical diagnosis was at first obscure, we have succeeded in establishing the presence of a ruptured air-containing viscus by a simple maneuver. After the initial negative fluoroscopic examination, the patient is placed upon his left side and is ordered to remain in that position. If the perforation is still patent, or, if previously sealed re-opens, air will escape into the abdominal cavity. This air can be detected after an interval of one to several hours following the first observation."

One consideration of examination in the upright position is the possibility of confusing gas in the stomach or splenic flexure of the colon with free peritoneal air. In a recent case this error was made—supposed air was seen in the upright position, but none in the left lateral decubitus position. No ulcer was found at operation.

In this series of 227 cases of perforated viscera at this hospital in the past 5 years, 19 cases, or 8 per cent, showed air under the diaphragm on the left side only, when erect. Some difficulty was encountered in trying correctly to interpret these cases.

ADVANTAGES OF THE LEFT LATERAL DECUBITUS POSITION

The advantages of the left lateral decubitus position are numerous; there are few possible disadvantages. One important advantage has already been mentioned; namely, the avoidance of unnecessary risk of leakage and spread of gastric contents. Other advantages may be listed under the headings: (2) time conservation and consideration of patient; (3) interference of subphrenic adhesions eliminated; (4) ease and accessibility of examination;

(5) reduction of expense of examination; (6) differentiation from subphrenic abscess; and (7) greater contrast on wet films in left lateral decubitus position. The possible disadvantages would be: (1) lungs not so well visualized; (2) interposition of bowel; and (3) overlying properitoneal fat line which might be mistaken for air.

Time conservation and consideration of patient. Time is an important element in these cases. There is no question as to the direct relationship between the mortality rate and the length of time elapsing after perforation before operation. However, as has been mentioned, it is often necessary for a period of time to elapse for a visible quantity of air (5 to 10 cubic centimeters) to accumulate beneath the diaphragm. One of the characteristics of a patient with a perforated ulcer is the fact that he will not move or allow himself to be moved. Eusterman and Balfour in their book *The Stomach and Duodenum* quote Moynihan who vividly describes the symptoms of a patient with a perforated ulcer: "The agony suffered by the patient is almost beyond belief . . . what strikes every onlooker is that the patient's body is rigid and motionless, *no slightest movement dare be attempted.*" How, then, can we stand or sit a patient up for several minutes who is in excruciating pain? This is unthinkable and not at all necessary when the left lateral decubitus position is used. It is now the practice at the San Francisco Mission Emergency Hospital to turn these patients on their left side immediately upon entrance. There is always some delay in history taking and physical examination. By the time the patient is brought to the x-ray department, some time has elapsed and a film may be taken at once.

Examination in the left lateral decubitus position is a much safer procedure than examination in the upright position. Patients who are in shock, as most of these patients are, are not placed in a position which is the reverse of the accepted treatment. Before this procedure was established, one patient who was in shock before being placed upright, died 2½ hours following the examination. His death was attributed partially to the trauma of the examination.

Adhesions. Adhesions may seal the subphrenic space. Many cases of perforated ulcers have histories of repeated attacks. Payne and Rigler noted, on experimental injection of air into patients with abdominal lesions, that in some cases the place where air was first seen was lateral to the right lobe of the liver, instead of above it. In one case, despite the establishment of a large diagnostic pneumoperitoneum of 1,400 cubic centimeters of carbon dioxide, no gas ever appeared under the right diaphragm and only a small portion under the left. This observation was interpreted as indicating extensive adhesions between the under surface of the diaphragm and the liver and spleen, and a subsequent laparotomy demonstrated the presence of an extensive tuberculous peritonitis. They made the conclusion: "It is obvious that in cases of this type, examination in the upright position, as usually done, would fail to reveal gas. Examination in the left lateral decubitus position is of very great value under such conditions, as gas can thus be demonstrated between the lateral abdominal wall and the liver even if the subphrenic space is sealed."

Ease of examination. Examination in the left lateral decubitus position is not only much easier and safer for the patient but is also a more simple technical procedure. One technician can handle the patient. No assistance is needed to hold the patient motionless in position. A portable machine may be used to take the film and indeed the examination may be done in the ward or in the admission room, either in the bed or on the guerney, without even moving the patient.

Expense. The objection may be raised that an additional film is expensive and could not be used as a routine procedure. This can be answered by the fact that a smaller film may be used (8 by 10 or 10 by 12) than is generally used for the upright examination. In the great majority of cases, an upright film will not be necessary. Follow-up examinations can be done with a total cost that is less than that of the ordinary one upright examination.

Differentiation from subphrenic abscess. In the case of a subdiaphragmatic abscess, Buckstein states: "While a subdiaphragmatic ab-

scess may be seen in the roentgen examination of the chest in the erect position, showing the elevation of the right diaphragm, the abdominal condition present is seen to best advantage in the roentgenogram of the abdomen in the lateral position." Payne and Rigler also add the statement that "information gained from a film made in the left lateral decubitus position, when taken with the upright, is often valuable in deciding whether an accumulation of gas seen under the diaphragm is free in the peritoneal cavity or localized in an abscess. We feel that a gaseous shadow which shifts with change in the patient's position is confirmatory evidence of this point."

Contrast greater on wet films in left lateral decubitus position. In a case of perforated viscus, the wet film must be examined. Contrast, then, is very important. The black line of air is seen to best advantage when in contrast to the white shadow of the liver in the left lateral decubitus position (Fig. 3). In the upright projection frequent irregularities in the central portion of the diaphragm and the overlying lower ribs also cause difficulty in interpretation. Often there is a low-grade pneumonitis and associated pleuritis which will obscure detail in the upright roentgenograph. In Case 1, this factor caused an erroneous diagnosis to be made (Fig. 4 a and b).

Fig. 1. The left lateral decubitus position.

Fig. 2. a and b, Position of the stomach in the upright and left lateral decubitus projections. The arrow in the left lateral decubitus projection points to a small collection of fluid barium in the base of the duodenal bulb with air above it. Note that the juxtapyloric area, the actual site of rupture in 80 to 90 per cent of cases, is below the fluid level in the upright roentgenograph and above it in the left lateral decubitus position. Air from a perforation in this area could escape only if the stomach were in the latter position.

POSSIBLE DISADVANTAGES

Pathological changes in lung missed. An objection that has been raised to the routine

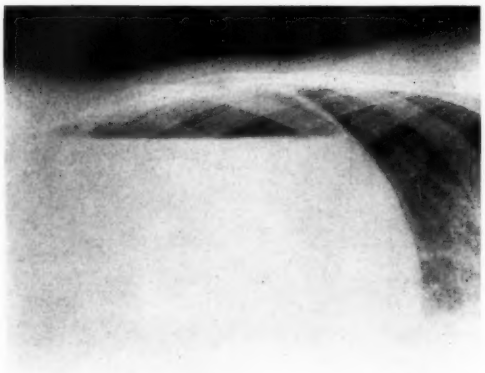

Fig. 3. Spontaneous pneumoperitoneum in the left lateral decubitus position. The greater contrast between the air collection and the liver enables the roentgenologist to visualize smaller collections with greater accuracy. This illustration shows that the base of the lower right lung can be well visualized with the patient in this position. If there were any pathological pulmonary change, it would readily be demonstrated here.

procedure of taking only left lateral decubitus films is that pathological changes in the chest may be missed. In this series of 232 cases, only 17, or 7 per cent, showed evidence of pneumonitis of the right base. This was shown equally as well in the left lateral decubitus position as in the upright position.

Moreover, even if pneumonitis were present with the perforation, the treatment of such will be essentially unaltered. Eight of the 17 cases with pneumonitis died. The 4 that were autopsied showed death to be due to "Generalized peritonitis following a ruptured ulcer, and terminal bronchopneumonia."

Interposition of intestine. Another disadvantage that might possibly be listed is that there may be an occasional loop of bowel interposed between the liver and diaphragm. This change is so rare as to be of negligible importance. We have seen it in only 1 of our cases and were able to differentiate free air from it (Case 2).

Properitoneal fat line. A questionable third disadvantage is that occasionally the properitoneal fat line might be confused with air between the lateral thoracic wall and the diaphragm. However, this should not give rise to mistaken diagnosis by the experienced observer.

SAN FRANCISCO HOSPITAL STUDY

At the San Francisco Hospital, during the past 5 years, 227 cases of proved perforated viscera had x-ray examinations in the upright position to ascertain the presence of pneumoperitoneum. Of these cases 173, or 76.2 per cent, showed air beneath the diaphragm; 54, or 23.8 per cent, did not. Sixty-eight had x-ray examinations in the left lateral decubitus position. Sixty-one or 89.7 per cent of these cases revealed pneumoperitoneum; 7, or 10.3 per cent, did not, a difference of approximately 13.5 per cent in favor of the left lateral decubitus position examination (Table I).

TABLE I.—COMPARISON OF TOTAL UPRIGHT AND TOTAL LEFT LATERAL DECUBITUS EXAMINATIONS

	Cases	Pneumoperitoneum	Percentage of positive diagnoses
Left lateral decubitus	68	61	89.7
Upright	227	173	76.2
Percentage difference			13.5

Another group of 63 cases of perforated viscera which had been proved by surgery or autopsy had examinations in both the upright and left lateral decubitus position. These 63 cases included 52 cases of perforated juxtapyloric ulcers, 3 cases of perforated lesser curvature gastric ulcers, 1 case of marginal ulcer after gastro-enterostomy, 4 cases of traumatic perforations, 1 case of spontaneous perforation of the large intestine, 1 case of perforation of the lower esophagus and diaphragm (following esophagoscopy), 1 case of ruptured appendix. The term "juxtapyloric" is used because often the operating and autopsy surgeons cannot agree as to which side of the pylorus the perforation occurs. In this series of 63 cases, in which both the upright and left lateral decubitus positions were used to attempt to demonstrate pneumoperitoneum, only 7 cases, or 11 per cent, did not show air in the left lateral decubitus position; 14 cases, or 22 per cent, did not show air in the upright position. This is a difference of 11 per cent (Table II).

The percentage of positive diagnoses of pneumoperitoneum in reported cases of perforated viscera in the literature is approximately 75 per cent. It was also approximately

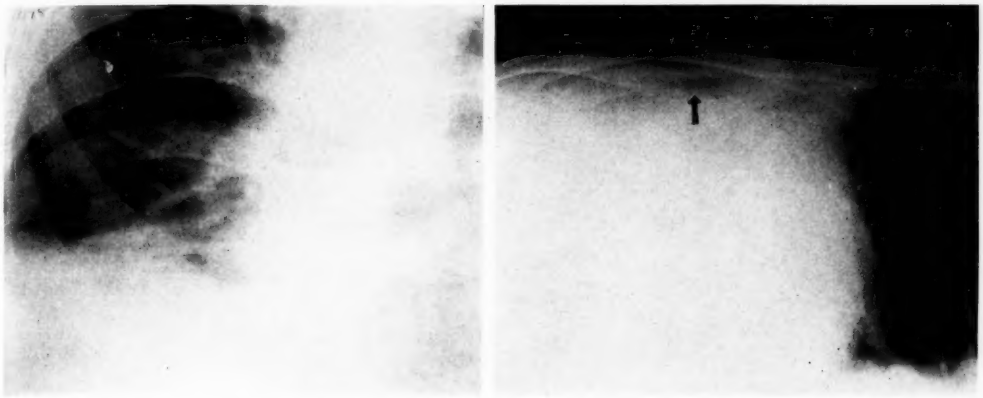

Fig. 4. a and b, Roentgenographic examination of the same patient (Case 1) in an upright and left lateral decubitus position. Pneumonitis at the right base obscures the pneumoperitoneum in the upright projection. Definite free subdiaphragmatic air can be visualized in the lateral roentgenogram.

this figure (76.2 per cent) that was obtained in this series when only the upright projection was used. According to this figure, we should expect that in our subsequent series of 63 cases, there would be 48 cases in which pneumoperitoneum would be demonstrated. Moreover, as pneumoperitoneum was demonstrated in 57 cases, we should expect that in 9 cases air could be seen only in the left lateral decubitus position. There were 8 cases in this series that did show air only in the left lateral decubitus position. In 1 case, and only 1, that of a stab wound in the right lower quadrant with perforation of the ileum, air was seen in the upright projection and not in the left lateral decubitus position.

In almost all our cases, when air could be seen in the upright film, it was much more clearly demonstrated in the left lateral decubitus position. A rough estimate of the area of air seen under the diaphragm in the upright position was compared with the quantity seen in the lateral position. This estimate was made by multiplying the length of the air column by the height in each case. This gave a ratio of 3:2 favoring the left lateral decubitus position.

TABLE II.—ANALYSIS OF SERIES IN WHICH BOTH UPRIGHT AND LEFT LATERAL DECUBITUS EXAMINATIONS WERE MADE

Total Cases—63

	Pneumoperitoneum				Air in only this projection	
	Positive	Per cent	Negative	Per cent	No. cases	Per cent
Left lateral decubitus	56	88.9	7	11.1	8	12.7
Upright	49	77.7	14	22.3	1	1.5
Percentage differences						11.2

CASE REPORTS

CASE 1. J. F., (Fig. 4 a and b) 60-year-old white male who, 4 days before entry, was seized with a sudden attack of excruciating abdominal pain arising in the left lower quadrant and radiating to the right at the level of the umbilicus, and gradually increasing in severity. Upon consulting a physician, he was advised to take soda and a bottle of citrate of magnesia. This tended to increase the pain, which became generalized. He was sent to another hospital where two enemas were administered, without relief. After a consultation and laparotomy was decided upon, he was transferred to this hospital. Physical examination disclosed a board-like abdomen distended throughout with generalized tenderness. X-ray report: "No evidence of subdiaphragmatic air; probably low intestinal obstruction." At that time (5 years ago), in spite of the fact that the left lateral decubitus film showed subdiaphragmatic air, it was not considered to be of significance because no air was seen in the upright. Operation was performed to relieve obstruction. The lower abdomen was explored but no obstruction was found. A cecostomy was performed. Because of the failure to find a lesion in the lower abdomen, an upper right rectus incision was made. Yellowish fluid was encountered and, upon exploration, a perforation of the stomach was found 1 centimeter proximal to the pyloric ring.

CASE 2. J. H., a 52-year-old white male, entered with history of inability to swallow solid food and a

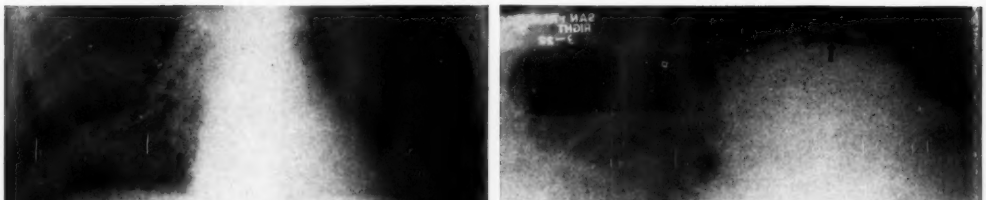

Fig. 5. a and b, Comparison upright and left lateral decubitus examinations (Case 4). A surgical note at time of operation states, "An upright film of the abdomen fails to demonstrate air beneath the diaphragm." The left lateral decubitus projection showed air, but evidently was disregarded by the surgeon. The upright film (Fig. 5a) shows the difficulty of interpretation when there is a question of air beneath the left leaf of the diaphragm only. Gas in the stomach and the splenic flexure of the colon may simulate or obscure pneumoperitoneum.

loss of 42 pounds in weight over a period of a month and a half. Patient was esophagoscoped on entry, and it was found impossible to pass the esophagoscope beyond a constricting lesion, apparently at the cardiac opening of the stomach. A biopsy of this tissue was taken which, upon sectioning, was found to be fat. Posterior-anterior and lateral roentgenograms made upright revealed no air under the diaphragm, in the chest or mediastinum. A left lateral decubitus film revealed air under the diaphragm. At operation no perforation was found. The patient expired 3 days later. A large annular carcinoma involving the cardiac orifice of the stomach and extending 12 centimeters into the esophagus was found at autopsy. There was a generalized peritonitis and a rent in the diaphragm along the suture line. Careful dissection revealed a small, well walled-off perforation on the posteromedial surface of the esophagus at the level of the esophageal hiatus of the diaphragm.

CASE 3. G. G., 53-year-old white male who had been in the hospital for 1 week under observation for either a supposed gastro-intestinal malignancy or coronary artery disease. Approximately 7 hours before being seen in the x-ray department, he developed sharp epigastric pain which soon radiated over the entire abdomen and to the left shoulder. He vomited once. Physical examination revealed a board-like rigidity of the abdomen. X-ray examina-

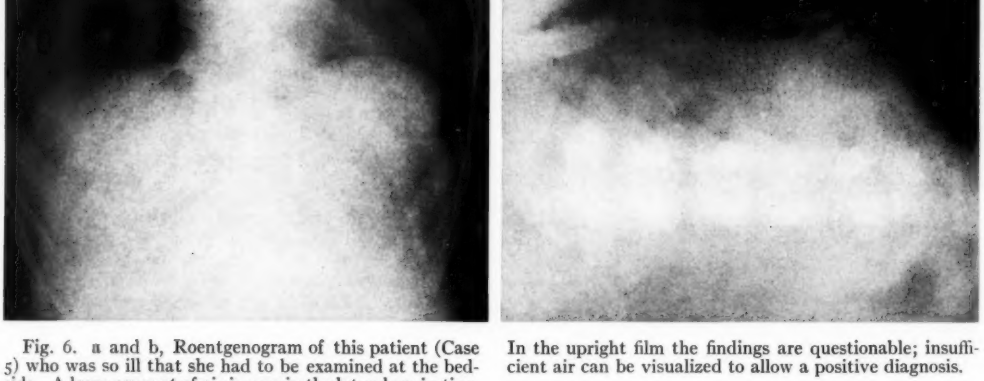

Fig. 6. a and b, Roentgenogram of this patient (Case 5) who was so ill that she had to be examined at the bedside. A large amount of air is seen in the lateral projection. In the upright film the findings are questionable; insufficient air can be visualized to allow a positive diagnosis.

tion revealed at first examination no air in either the upright or the left lateral decubitus position. After lying on his left side for 20 minutes, air was seen beneath the diaphragm in the left lateral decubitus position. Operation was performed and a perforated ulcer, 8 millimeters in diameter, was found on the anterior surface of the duodenal bulb.

CASE 4. O. H. (Fig. 5 a and b), 51-year-old white male, entered complaining of sudden onset of agonizing abdominal pain radiating to his right shoulder. The patient vomited three times after onset. There was a past history of epigastric pain, relieved by soda. Physical examination revealed board-like rigidity of the abdomen. A surgical note at the time of operation stated: "An upright film of the abdomen fails to demonstrate air beneath the diaphragm." The left lateral decubitus projection showed air, but evidently was disregarded by the surgeon. At operation a 6 millimeter perforation, 1 centimeter proximal to the pylorus, was found on the anterior gastric surface.

CASE 5. D. T. (Fig. 6 a and b), 45-year-old negro female, entered hospital complaining of anorexia, loss of weight, and tarry stools. On the day after admission she developed severe non-radiating abdominal pain. Physical examination revealed a board-like abdomen. Patient was so ill that only a portable x-ray examination was possible. The patient could not be placed in the total upright position, but, in a 45 degree upright projection. No air was seen under the diaphragm. However, in the left lateral decubitus position, a considerable amount of air was seen. Patient refused operation and died the next day. Autopsy revealed an 8 millimeter perforation on the lesser curvature of the stomach, 6 centimeters proximal to the pylorus. There was also a small posterior perforation which was, however, sealed by adhesions to the pancreas.

CASE 6. E. V., 55-year-old white male, entered hospital complaining of severe abdominal pain of 20 hours' duration. Patient had history of long-standing "heart burn" and belching. Physical examination revealed râles at both bases. The abdomen showed board-like rigidity. X-ray report: "No gas can be definitely identified beneath either leaf of the diaphragm in the upright radiograph. A small bubble is present under the right leaf in the left lateral decubitus position, indicating a visceral perforation." Patient was treated conservatively by Wangensteen suction. He expired the following day. At autopsy a generalized peritonitis was found, the result of a perforated duodenal ulcer.

CASE 7. A. E. (Fig. 7), 72-year-old white male, entered the hospital complaining of severe epigastric pain of 3 days' duration. Physical examination revealed generalized abdominal tenderness most marked in the right lower quadrant. There was no guarding. No masses were palpable. The upright examination was questionable as to the presence of air, but there was definite air shown in the left lateral decubitus position. Due to the poor condition of the patient, conservative treatment was decided upon. The patient expired the following day. Postmortem examination revealed a ruptured appendix with general peritonitis.

Fig. 7. Pneumoperitoneum in a case of a ruptured appendix (Case 7). Air was seen to best advantage in the left lateral decubitus position. This examination may prove of value in cases in which there is a possibility of a perforated appendix.

SUMMARY

1. The rationale of, and the advantages and possible disadvantages of the left lateral decubitus position are presented. The advantages in favor of this position far outweigh any possible disadvantages.

2. In a series of 227 cases of proved perforation, in which the upright film was taken, pneumoperitoneum was shown in 173 cases, or 76.2 per cent. In a series of 68 cases, in which the left lateral decubitus position was taken, pneumoperitoneum was demonstrated in 61 cases, or 89.7 per cent, a difference of 13.5 per cent in the two series.

3. Analysis of a series of 63 cases, in which both the upright and left lateral decubitus positions were used, showed pneumoperitoneum to be demonstrated in 77.7 per cent in the upright position and 88.9 per cent in the left lateral decubitus position. In 1.5 per cent it was shown only in the upright projection and not in the left lateral decubitus projection. In 12.7 per cent it was demonstrated only in the left lateral decubitus projection and not in the upright projection. Thus, at this hospital, about 13 per cent more positive diagnoses were possible by the use of the left lateral decubitus position.

4. One case of pneumoperitoneum following ruptured appendix is included in this series. This is the only proved case in this hospital in which this procedure has been done. Only a few such cases have been reported in the literature. It is possible that this position might prove to be a valuable aid in diagnosing obscure or questionable cases of ruptured appendix.

CONCLUSION

The left lateral decubitus position is the position of choice in the roentgen examination of all cases of possible perforated viscera. If no air is seen, the upright position may be used as a supplementary procedure. In our experience, however, this latter examination has been of only occasional assistance.

It should be remembered that not only is the left lateral decubitus position the position of choice for roentgen examination, but it also minimizes the escape of gastric contents into the peritoneal cavity during the time necessary before surgical procedure is instituted.

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PREGNANCY AND EXPERIMENTAL PULMONARY TUBERCULOSIS IN RABBITS

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UNCERTAINTY regarding the effect of pregnancy on tuberculosis is, as Krause (1935) has pointed out, mainly due to the following factors: (1) failure of most investigators to include suitable controls, and (2) failure, on the part of far too many who treat the condition, to separate the effect of pregnancy from those of parturition and the puerperium. To these factors may be added one other, namely, a seemingly complete lack of precise experimental evidence regarding the relation of pregnancy to pulmonary tuberculosis.

Data concerning the effects of pregnancy and parturition on experimental pulmonary tuberculosis in rabbits are presented in this discussion.

EXPERIMENTAL

The observations to be recorded herein were made during the course of a series of studies (1935, 1940) of the x-ray and necropsy findings in experimental pulmonary tuberculosis in rabbits. Two hundred and forty rabbits were used in the series of studies. The animals may, for the purpose of the present study, be divided into two groups, namely: (1) those which were injected intratracheally with a measured quantity of human tubercle bacilli (H37) and in which the disease was essentially retrogressive, and (2) those which were injected intratracheally with graded doses of bovine tubercle bacilli (B_1) and in which the disease was essentially progressive.

The published accounts (1935, 1940) of the foregoing studies include descriptions of the manner in which the rabbits were injected and of the procedures employed in tracing the evolution of the pulmonary lesions. They do not, however, contain mention of the fact that in spite of efforts which were made to keep the sexes apart, a few of the animals gave birth to young on one or more occasions. The procedure adopted when a rabbit gave birth to young was to record the date that the litter was born and to destroy the young before they had a chance to suckle.

An analysis of the records of the 240 rabbits included in the series of studies mentioned showed that 21 rabbits gave birth to mature litters on one or more occasions. Nine of these 21 animals were in the group which was injected intratracheally with a measured dose of human tubercle bacilli, the 12 remaining, in the group which was injected with graded doses of bovine micro-organisms.

RABBITS INJECTED INTRATRACHEALLY WITH HUMAN TUBERCLE BACILLI

These rabbits, 134 in number, may be divided into two groups, namely: (1) those which were healthy prior to the intratracheal injection and in which primary tuberculosis developed, and (2) those which had been inoculated in the groin with an attenuated strain of tubercle bacilli (R_1) and in which reinfection tuberculosis developed immediately following the intratracheal injection. All of the rabbits in both groups were injected intratracheally with a single dose (1 mgm.) of human tubercle bacilli (H37). X-ray and necropsy examinations showed that the resulting lesions in the rabbits in both groups, though strikingly different in mode of development, were essentially retrogressive in nature. The lesions regularly progressed during the first, and part of the second, months following the intratracheal injection; and then, with a few exceptions, retrogressed leaving either no demonstrable lesion or only a small residual focus in the pulmonary parenchyma. Most of the rabbits were killed to permit of study of the lesions at different stages of the disease. Only 1 animal actually died of tuberculosis.

From the New York State Hospital for Incipient Pulmonary Tuberculosis, Ray Brook, New York.

Four of the 76 rabbits which had primary pulmonary tuberculosis gave birth to young. The young arrived in every instance after the original abnormal shadows in the chest x-ray pictures had disappeared and when, presumably, the lesions were resolving or quiescent. One rabbit (No. 199) gave birth to young on 3 occasions, in the third, fourth, and fifth months, respectively, following the intratracheal injection. Another rabbit (No. 314) had a single litter in the fifth month. These 2 animals were killed in the sixth month, at which time only small residual foci were found in the lungs. Of the 2 remaining rabbits, 1 (No. 200) gave birth to 5 litters during the second year following the intratracheal injection, and the other (No. 201) gave birth to young on 6 occasions. The litters of the latter animal arrived in the fourth, fifth, ninth, eleventh, fourteenth, and twentieth months, respectively. No lesions were found in the lungs of these animals when they were killed approximately 1 year and 9 months following the intratracheal injection. A comparison of the x-ray and necropsy findings in these 4 rabbits with the findings in males and non-pregnant females failed to reveal any difference in the manner in which the disease developed and in the end-results obtained.

Of the 58 rabbits which had reinfection tuberculosis, 5 gave birth to young. Two of these animals carried litters through the early phases of the disease. The 3 remaining gave birth to young during the later phases of the disease. One rabbit (No. 205) had litters in the first, second, and third months, respectively, following the intratracheal injection. Another animal (No. 208) had a single litter in the third month. Two (Nos. 212 and 138) of the 3 remaining rabbits gave birth to young on 1 occasion. The fifth animal had a litter in the twenty-first month and contained several well developed fetuses when it was killed approximately 1 year and 10 months following the intratracheal injection. The x-ray and necropsy findings in these 5 rabbits were, as far as could be ascertained, different in nowise from the findings in males and non-pregnant females similarly injected and killed at comparable periods.

RABBITS INJECTED INTRATRACHEALLY WITH BOVINE TUBERCLE BACILLI

These rabbits, 106 in number, may, like the above described animals, be divided into two groups, namely: (1) those with primary tuberculosis, and (2) those with reinfection disease. Each of these groups, in turn, consists of animals injected intratracheally with a single dose of either 0.1 or 0.5 or 1.0 milligram of bovine tubercle bacilli (B1). X-ray and necropsy studies of these rabbits revealed striking differences in the manner in which primary and reinfection tuberculosis develops and clearly demonstrated the rôle of dosage in both types of disease. The course of events in these rabbits was somewhat as follows: Lesions developed slowly in the lungs of the rabbits with primary tuberculosis; rapidly in the lungs of the animals with reinfection disease. By the end of the fourth or the sixth week, however, the lungs of all of the rabbits contained large areas of tuberculous pneumonia. These pneumonic areas underwent a remarkable degree of resolution in succeeding weeks. The lungs of the rabbits injected with the smaller quantities of micro-organisms (i.e., 0.1 and 0.5 mgm.) frequently contained, by the end of the fourth or the sixth month, only minute residual foci. In a few of the rabbits, animals with reinfection disease induced by 0.1 milligram of bacilli, these lesions remained quiescent for periods of 1½ to 2 years. These animals were killed. In most of the rabbits, however, the residual foci gave rise, after latent periods of a few months, to rapidly progressive pulmonary tuberculosis. All of these animals, except those which were killed to permit of study of intermediate stages of the disease, died of widespread tuberculosis.

Five of the 55 rabbits with primary tuberculosis gave birth to young on one or more occasions. Three of these animals were injected intratracheally with 0.1 milligram of micro-organisms, 1, with 0.5 milligram, and 1, with 1.0 milligram. The 3 animals injected with the smallest dose of bacilli each had 1 litter. The litters arrived in the third, the fifth, and the twelfth months. Two of the mothers (Nos. 356 and 470) were killed a few days after the young were born. The third mother (No. 393) was killed 1 year and 3

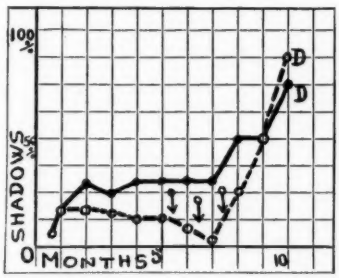

Fig. 1.[1] Primary tuberculosis. 0.5 mgm. B_1. Rabbit 377, male; rabbit 378, female.

[1]In all figures axes of ordinates equal extent of abnormal shadows, in percentage of lung fields of chest x-ray pictures; axes of abscis as equal interval following intratracheal injection, in months.
Male, ————; female, ——o——; birth of young, ♀.

months after the intratracheal injection. The rabbit injected with 0.5 milligram of bacilli (No. 378) gave birth to 3 litters, in the sixth, seventh, and eighth months, respectively. The animal injected with 1.0 milligram of micro-organisms (No. 115) contained several well developed fetuses when it was killed in the fifteenth month. A critical analysis of the x-ray and necropsy findings in these 5 rabbits and in non-pregnant females and males injected with similar quantities of bacilli, failed to show that pregnancy and parturition had significantly modified the course of the disease.

Figure 1 contains curves of 2 rabbits, obtained by plotting the percentage of the lung fields occupied by abnormal shadows against the interval following the intratracheal injection. The curve of the control animal, a healthy male (No. 377) injected intratracheally with 0.5 milligram of bacilli on the same day as the female (No. 378), is in solid lines. The

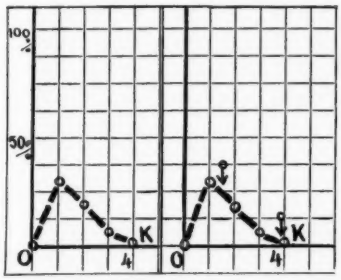

Fig. 2. Reinfection tuberculosis. 0.1 mgm. B_1. Rabbit 433, virgin female; rabbit 432, female.

curve of the female is in broken lines and circles. The arrows indicate the time at which the female gave delivery.

Young were born to 7 of the 51 rabbits with reinfection tuberculosis. Four of these 7 animals were injected intratracheally with 0.1 milligram of bacilli; 2, with 0.5 milligram; and 1, with 1.0 milligram.

The findings in the four rabbits injected intratracheally with the smallest dose (0.1 milligram) of bacilli were as follows: One animal (No. 432) gave birth to a litter in the second month and was pregnant when killed in the fifth month. The x-ray and necropsy findings in this animal were similar to those in a non-pregnant female (No. 433) which was killed at the same time. Figure 2 shows that the curves of these 2 animals are practically identical. Another rabbit (No. 424) gave birth to young in the ninth month and was killed a few days later. Serial x-ray pictures of this animal disclosed that the disease, after undergoing marked retrogression, spread in the sixth month and again

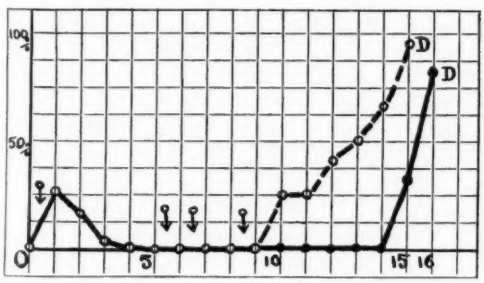

Fig. 3. Reinfection tuberculosis. 0.1 mgm. B_1. Rabbit 345, male; rabbit 343, female.

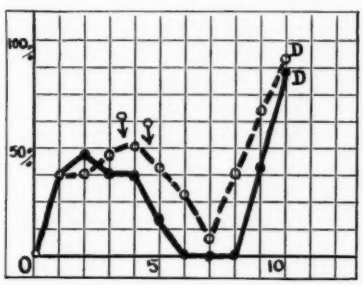

Fig. 4. Reinfection tuberculosis. 1.0 mgm. B_1. Rabbit 388, male; rabbit 387, female.

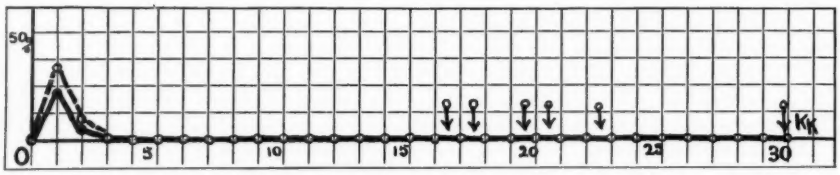

Fig. 5. Reinfection tuberculosis. 0.1 mgm. B_1. Rabbit 340, male; rabbit 341, female.

in the ninth month. Necropsy examination revealed areas of gray consolidation studded with caseous foci and partially surrounded by fibrous tissue in both lungs. These lesions were comparable in every way to the lesions in the lungs of control animals killed soon after new shadows began to appear in the chest x-ray pictures. The third rabbit (No. 343) gave birth to litters on 4 occasions and died of widespread tuberculosis 1 year and 3 months after the intratracheal injection. The x-ray and necropsy findings in this animal were, in all essentials, similar to the findings in some of the male rabbits injected with comparable quantities of the same suspension of tubercle bacilli. Figure 3 depicts the curves of this animal and of a male (No. 345) which died at a comparable period. The fourth rabbit (No. 341) gave birth to young on 5 occasions and was pregnant when killed. This rabbit, like a few of the male rabbits similarly injected, failed to show any evidence of recrudescence of the disease. The animal was killed 2½ years after the intratracheal injection. Necropsy examination disclosed a few small gray tubercles and minute scars in the left lung. These lesions were similar, in all essentials, to the lesions in the lungs of a male rabbit (No. 340) injected with a comparable quantity of the same suspension of bacilli and killed on the same day. The curves of rabbits No. 341 and 340 appear in Figure 5.

One of the 2 rabbits injected intratracheally with 0.5 milligram of bacilli which gave birth to young, had 2 litters; the other, 10 litters. The former (No. 372) gave birth to young in the eleventh and twelfth months and died of extensive ulcerative pulmonary tuberculosis approximately 1 year and 1 month following the intratracheal injection. The x-ray and necropsy findings in this rabbit were similar to those in most of the animals injected in a comparable manner. The second rabbit (No. 391) gave birth to litters in the first, second, third, fourth, sixth, seventh, eighth, ninth, tenth, and eleventh months, respectively. This animal, unlike all of the other animals similarly injected, failed to present any evidence of recrudescence of the disease. The animal was killed 2 years after the intratracheal injection, at which time only a few small areas of gray consolidation were found in the lungs. Figure 6 contains the curves of this animal (No. 391).

The one rabbit (No. 387) injected intratracheally with 1.0 milligram of bacilli which gave birth to young, had litters in the fourth and fifth months and died of widespread tuberculosis in the tenth month. The pregnancies, as far as could be ascertained from a study of the x-ray and necropsy findings in this animal and in other animals similarly injected, had no effect on the course of the disease or the end-results. Figure 4 contains curves of this animal (No. 387) and likewise of a male animal (No. 388) which had been injected with a comparable portion of the same suspension of bacilli.

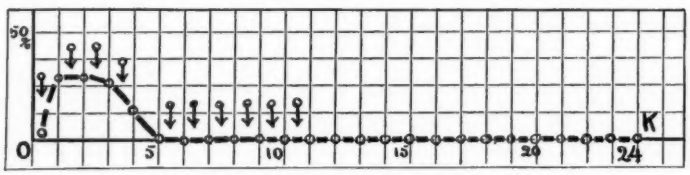

Fig. 6. Reinfection tuberculosis. 0.5 mgm. B_1. Rabbit 391, female.

SUMMARY

The experimental lesions in the lungs of the 240 rabbits, from which the 21 animals which form the basis for the present study were drawn, were, in many respects, similar to pulmonary tuberculosis in human subjects. They included lesions of primary and reinfection types induced by both human and bovine tubercle bacilli. The lesions in rabbits injected intratracheally with human tubercle bacilli were essentially retrogressive; those in rabbits injected with bovine micro-organisms were, with a few exceptions, essentially progressive.

Of the 21 rabbits which gave birth to young, some had one litter; others had several litters. Young were born in early, intermediate, and late stages of both the essentially retrogressive and the essentially progressive forms of tuberculosis.

The present study failed to show any significant difference in the pathogenesis of experimental pulmonary tuberculosis in rabbits which did and did not give birth to young.

It seems reasonable, therefore, to conclude that pregnancy has no apparent effect on experimental pulmonary tuberculosis in rabbits.

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THE PHARMACODYNAMIC EFFECTS OF CERTAIN OXYTOCICS UPON TUBAL CONTRACTIONS IN THE RHESUS MONKEY

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IN order to study the effects of oxytocics several methods of assay have been devised. In some instances the activities of fragments of muscle removed from the excised uterus and continuously bathed in suitably oxygenated solutions, have been determined by attaching delicate hooks to the muscle and registering the contractions upon a smoked drum. In the living animal, and in woman, balloons have been placed within the uterine cavity and the pressure effects have been transmitted to the recording pen. In addition, oxytocics have been injected into the living animal and the visible effects upon the intact organs have been studied.

Generally, when the methods in question have been employed, the dynamic effects have not been measured in millimeters of mercury. Having the desirability of such measurements in mind during the course of other experiments upon the rhesus monkey, we have recorded observations which, it appears, are of interest respecting the strength of tubal and uterine contractions in this animal resulting from the administration of certain oxytocic substances employed in obstetrics and gynecology. In the majority of instances, obstetrical pituitrin was employed, but in a few cases thymophysin and ergotrate were administered.

The observations were made upon animals anesthetized with a solution of pentobarbital sodium, and in this connection a recent statement by Adair and Pearl is pertinent. The latter investigators in a clinical study found that this drug administered orally in 3 grain doses produced no appreciable change in uterine activity. Although there was a slight increase in the interval between the individual contractions, the general tone and the amplitude were unaltered, and the tracings recorded showed as strong a uterine activity as before administration of the drug.

In our experiments the Voegtlin unit by which standard solutions are assayed was not used, but we employed the standard solutions administered clinically. The dosage, generally from ½ to 1 minim, was increased to 7 minims in the case of one animal, and in all instances was injected intravenously by means of a tuberculin syringe. The apparatus employed to record the contractions was that used in the test for tubal patency. The effect of the drug was noted by the change in rhythm of the contraction-relaxation waves produced by the passage of carbon dioxide through the uterus and tubes, while the variations in pressure were recorded upon the kymograph.

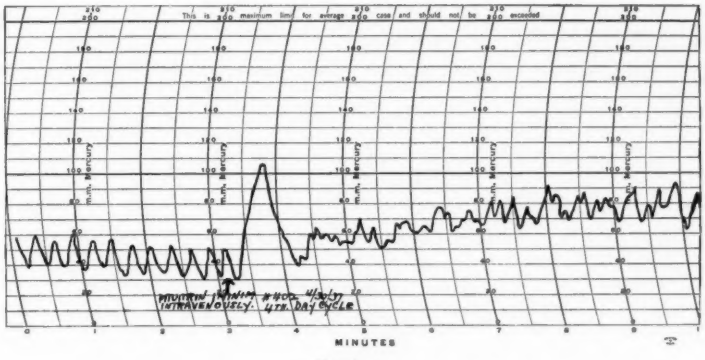
This brief paper is not intended to give a detailed report upon the effects of the substances mentioned since the observations are too few. Our wish is merely to record the possibility of using uterotubal insufflation as a medium by which, with the aid of a kymograph, it is possible to demonstrate the changes in pressure induced by the hypodermic injection of oxytocics.

As far as our observations go, we endeavored to note the latent period before the effect of the drug was exhibited, the extent to which the peristaltic wave was affected, the variation in the frequency and amplitude of oscillations when the contraction relaxation wave was not obliterated, the duration of the effect of the drug, and, finally, how these effects squared with the Knaus-Ogino theory.

DESCRIPTION OF TECHNIQUE

The uterine cervix was exposed according to a method previously described by us (2).

From the Department of Obstetrics and Gynecology, Yale University School of Medicine.
Aided by a grant from the Research Fund of the Yale University School of Medicine.



Graph 1.

The cannula attached to a uterotubal insufflation apparatus was introduced into the uterine cavity and held firmly by Allis forceps grasping each cervical lip while pressing the obturating acorn against the cervical orifice to prevent leakage of carbon dioxide. The rate flow was as a rule limited to 3 to 4 minutes for the passage of 60 cubic centimeters of carbon dioxide. At this rate absorption of the carbon dioxide within the peritoneal cavity nearly approximated its insufflation rate and the abdominal cavity was spared voluminous distention when the procedure was carried out for 15 to 30 minutes or longer.[1]

It must be noted that the contraction-relaxation phenomena observed on the kymograph when carbon dioxide is passed through the uterus are generally synchronous with rhythmic contractions of the oviducts and only rarely with those of the uterus. During uterotubal insufflation, as has been proved conclusively by I. C. Rubin in the human and sow, S. Wimpfheimer and M. Feresten in the rabbit, and A. H. Morse and I. C. Rubin in the rhesus monkey, the uterus remains distended throughout the insufflation, its contractility being coincidently paralyzed. Only when the carbon dioxide does not traverse the oviducts, but is allowed to regurgitate from the cervix at levels of pressure inadequate to overcome the resistance of the uterotubal junction are uterine contractions and relaxations procured.

[1] Marked abdominal distention can be relieved at once by introducing a No. 18 hypodermic needle into the peritoneal cavity.

Table I shows the number of observations upon each animal of the group and the day of the cycle upon which the experiment was performed.

TABLE I.—OBSERVATIONS AND DAY OF CYCLE

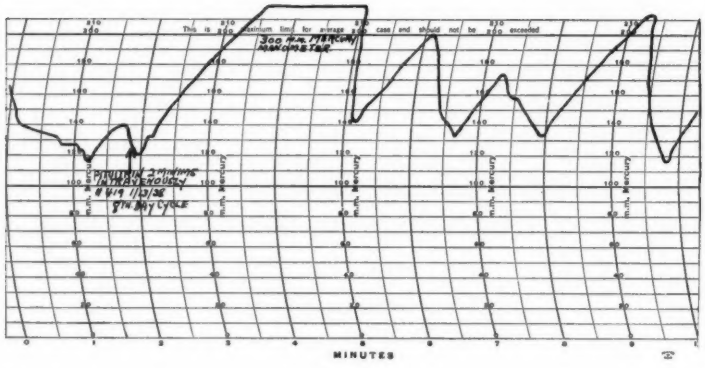
Number of observations	Day of cycle
Animal 431—5	2–5–18–23–28
Animal 390—8	5–8–10–12–13–13–15–22
Animal 419—5	8–11–14–15–26
Animal 389—7	7–12–14–19–19–23–26
Animal 402—4	4–18–18–25
Animal 373—1	7
30	

In each of animals 389, 390, and 402 experiments were done upon corresponding days during two different cycles.

ANALYSIS OF RESULTS

Thirty observations were conducted and the accompanying curves were selected from the kymographic recordings obtained. In most instances the contractions and relaxations registered during carbon dioxide uterotubal insufflation are manifestations of tubal but not of uterine muscular activity.

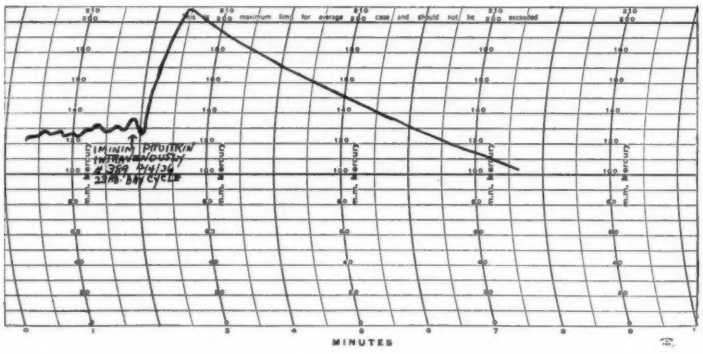
The latent period before the effect of the injected pituitrin was observed varied in the different animals and in the same animal upon different trials. In the accompanying graphs it will be seen that the interval from injection to effect was from 30 to 40 seconds. However, during other experiments, the tables and graphs of which have been omitted, we found



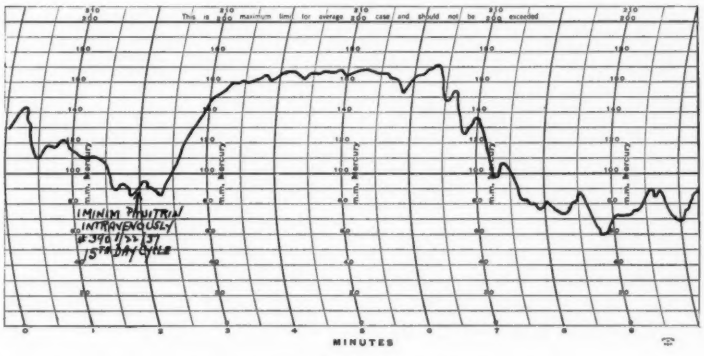
Graph 2.

the shortest interval to be 2 seconds and the longest 2 minutes. In the same animal the rapidity of reaction varied from 15 seconds to 2 minutes. In general the effect was produced within 15 to 68 seconds of the injection. No definite relationship between the oxytocic effect and the phase of the cycle was apparent. The duration of the effect likewise varied in the same and in different animals and again was independent of the phase of the cycle. Thus in animal 402, Graph 1, the effect of 1 minim of the drug was prolonged approximately 1 minute, after which there returned atypical tubal contractions as contrasted with the rhythmic waves which were present before the administration of pituitrin. In animal 389, Graph 3, the effect of 2 minims persisted for 5½ minutes, during which tubal contractions were inhibited. In animal 390, Graph 4, tubal contractions returned 1½ minutes following the intravenous injection of 1 minim of the drug, but a pressure of 160 to 170 millimeters mercury was maintained for 3½ minutes. At the end of this period there was an intermittent drop when the contractions resumed the character noted before the injection. Study of our numerous curves showed the shortest duration of effect to be 3 minutes, the longest 26 minutes, and the average from 3 to 15 minutes.

The pressure elevation measured in terms of millimeters of mercury varied considerably in the same and in different animals without exhibiting any striking trend with reference to the first or second half of the cycle. In animal 402, Graph 1, there was a rise from 50 to 105 millimeters of mercury; in animal 419, Graph 2, a rise from 130 to 300 with com-



Graph 3.



Graph 4.

plete obliteration of the tubal contractions noted before the injection; in animal 389, Graph 3, a rise from 125 to 208; in animal 390, Graph 4, a rise from 86 to 165 millimeters of mercury. In the complete series of experiments, the average elevation of pressure following the injection of pituitrin varied from 40 to 92 millimeters of mercury.

The observations respecting the oxytocic effect of thymophysin were too few to warrant conclusions. Only one definite effect was noted in four trials in as many different animals. Two experiments with ergotrate were without effect.

CONCLUSIONS

The method of uterotubal insufflation with the aid of the kymograph as employed for the diagnostic test of tubal patency, has been utilized to determine the oxytocic effects of pituitrin, thymophysin, and ergotrate upon the oviducts of the rhesus monkey. The pharmacodynamic effects have been measured in terms of millimeters of mercury and the duration of the effect, and the influence of the drug upon the character of tubal contractions have been studied. An advantage of the method is the possibility of determining oxytocic effects upon the intact tubes and uterus in the living animal.

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CLINICAL SURGERY

RESECTION OF A PORTION OF THE THORACIC ESOPHAGUS FOR CARCINOMA

A Report of Two Cases

B. NOLAND CARTER, M.D., Cincinnati, Ohio

THE purpose of this paper is to report 2 cases of carcinoma of the thoracic esophagus which were operated upon by the technique of Torek, to suggest an additional step in his procedure, and to offer a means of controlling the esophageal fistula which is a sequel of the operation. In Figures 1 to 9 an attempt is made to illustrate the operation more clearly than has been done in the past.

CASE REPORTS

CASE 1. C. E., Cincinnati General Hospital No. 84941. A 60 year old white male laborer entered the medical service of the Cincinnati General Hospital on January 13, 1938, with the chief complaint that he had been unable to swallow either liquid or solid food for 2 days.

Six months prior to entry into the hospital the patient suddenly felt that "solid food would not go down." Following this he noted a progressive but intermittent dysphagia. At first he was able to eat soft food and puréed vegetables, but no meat or heavy foods would pass. Then suddenly he would have difficulty in swallowing liquids. These attacks would come and go for a period of 5 months. At times he would be able to swallow without any difficulty whatsoever for 3 or 4 days, and then the esophagus would suddenly shut off and he would have to vomit whatever he ate. For several weeks prior to entry he was able to take only liquids and soft boiled eggs, when suddenly he was unable to swallow anything. In 6 months his weight fell from 142 to 101 pounds.

The patient was a markedly dehydrated and emaciated residue of what had been a fairly well developed male of 60. He was alert and well oriented. The following were the only positive findings. The subcutaneous tissues showed evidence of marked dehydration. There was no adenopathy. The mucous membranes were of good color. The 4 remaining teeth were very carious. The chest was emphysematous in type. Heart and lungs, physiological. Blood pressure was 128/80. Brachial and radial vessel walls showed a moderate amount of atheroma. The liver edge was palpable just at the costal margin. The spleen and kidney were not palpable.

The red blood cells numbered 4,400,000; white corpuscles, 11,200; hemoglobin, 12.5 grams. The urine was negative except for occasional granular and hyaline casts. Wassermann reaction was negative; urea, 12 milligrams per 100 cubic centimeters; carbon dioxide, 49 volumes per cent.

X-ray examination revealed an irregular obstruction in the esophagus at the level of the ninth dorsal vertebra. This was practically complete, only a thin trickle of barium passing into the stomach. Esophagoscopy was done, and an obstruction met with 22 inches from the incisor teeth. An irregular ulceration was seen at the point of the obstruction and a biopsy was taken from it. The first biopsy was unsatisfactory, but a second one showed the tumor to be a squamous cell carcinoma.

The patient was given parenteral fluids and transferred to the surgical service where a Janeway gastrostomy was performed January 24, 1938. There were no nodules in the liver and no glands were noted on the lesser curvature of the stomach. The postoperative course was uneventful. The patient gained 4 pounds in weight. A left-sided pneumothorax was instituted. The patient was transfused with 500 cubic centimeters citrated blood.

On February 22, 1938, under cyclopropane anesthesia, the left pleural cavity was entered through a long incision made in the seventh intercostal space, extending from the nipple line to the interscapular region and then up to the region of the third rib. The seventh, sixth, fifth, and fourth ribs were cut near their attachment to the spine. After mobilizing the left lung from many veil-like adhesions, the phrenic nerve was crushed and an incision was made through the parietal pleura over the esophagus from the aortic arch to the diaphragm. By sharp and blunt dissection the esophagus was freed from the aortic arch to the diaphragm. The right vagus nerve was quite adherent to the tumor, and many branches had to be sacrificed. The left vagus nerve was readily freed from the tumor. The tumor was found to be quite small and to lie at the junction of the middle and lower thirds of the esophagus. The diaphragm was not opened widely. The esophagus was divided between pursestring ligatures of silk, and an attempt was made to invert the esophagus into itself. The pursestring tore out and soiling occurred. Inversion was finally accomplished but with difficulty and more soiling. The proximal stump was carbolized and protected with gutta percha, which was tied over the end of the esophagus with braided silk. The esophagus was then separated above and below the arch of the aorta by sharp and blunt dissection. This dissection was then carried farther up into the region of the suprasternal notch. A small incision was made through the skin and plasma in this region. Cutting down against a finger which was pushing into the suprasternal notch from within the chest, the thoracic cavity was entered. The esophageal stump was then brought out through the incision in the neck and allowed to hang down the anterior chest wall. The thorax was then closed with 3

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Fig. 1. The exposure on opening the thorax. The dotted lines show the incision in the pleura overlying the esophagus. The course of the skin incision is shown in the insert.

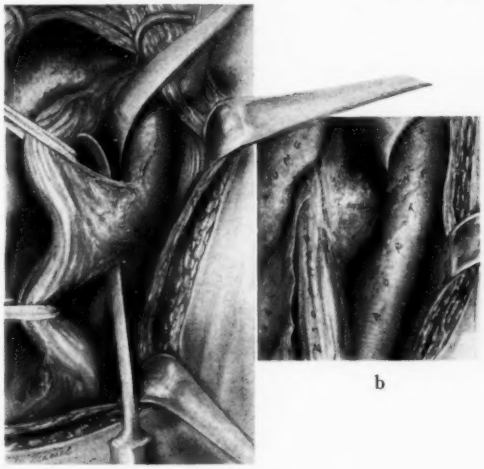
pericostal silver wires following inflation of the lung by means of positive pressure. The muscle layers were approximated with a running suture of No. 2 chromic catgut. The skin was closed with interrupted sutures of fine silk. Returning to the esophageal stump, a skin tunnel 4 centimeters long was made connecting an incision in the second interspace with that in the suprasternal notch and the esophagus and attached tumor brought through it. The excess portion of the esophagus containing the carcinoma was then removed and the edges of the esophagus sutured to the edge of the skin incision with fine silk. The patient received 1500 cubic centimeters of blood during the operation, but stood the operative procedure quite well and was returned to the ward in good condition.

The gross specimen consisted of a section of esophagus 6 centimeters long. The wall was 1½ centimeters in thickness. There was an annular constricting ring at one end, which was hard and nodular and composed of neoplastic tumor. No fungating mass was found.

Microscopic sections showed that the normal structure of the wall had been partially destroyed by neoplastic growth. The cells of the growth were rather large and moderately dark staining. They were arranged in indefinite layer sheets and sometimes in whorls. There was fair cellular differentiation and mitotic figures were not numerous, suggestive of a rather slowly growing tumor. Much of the muscularis was still intact and some normal glands could be found. In addition to the tumor formation there was also an inflammatory process, manifested by the presence of round cells closely packed in certain focal areas.

Fig. 2. The esophagus has been freed by sharp and blunt dissection from the diaphragm to the lower margin of the tumor and from the aortic arch to the upper margin of the growth.

Twenty-four hours after operation the patient's temperature rose to 105 degrees (rectal), pulse to 132, and respirations to 26, and he began to raise large amounts of



a b

Fig. 3. a, The growth is being dissected off the aorta. b, The growth has been completely freed from the aorta.

Fig. 4. The esophagus is being freed by blunt dissection from under the aortic arch. Several small arteries enter the esophagus here and must be isolated and ligated separately.

thick tenacious sputum. A diagnosis of atelectasis of the left lung was made, which cleared promptly with hyperventilation, turning of the patient, and encouraging him to cough, so that his temperature dropped to 100 degrees, pulse to 88 within 12 hours.

Within 48 hours after operation the patient was taking his hourly gastrostomy feedings. The temperature ranged around 99 to 101 degrees for 6 days. X-ray examination at this time revealed a rather uniform increased density of the left hemithorax, which was interpreted as a combination of atelectasis with associated pleural effusion. On aspiration 50 cubic centimeters of straw colored fluid, from which hemolytic streptococci were cultured, were removed. Several subsequent cultures of aspirated fluid were negative. A low grade infection developed in the lower third of the wound. On March 10, 1938, the patient developed an intractable diarrhea. Gastric analysis showed no free or combined hydrochloric acid. The addition of 10 cubic centimeters of tenth normal hydrochloric acid to each feeding completely checked the diarrhea. On March 15, 1938, a closed thorocotomy for streptococcus empyema was done, and on March 30, 1938, rib resection was performed in order to drain the remaining empyema cavity more adequately.

Three weeks after operation feedings were begun by mouth, the esophageal stoma and the gastrostomy being connected by a rubber tube. Considerable leakage occurred around the tube, and an intratracheal catheter with balloon attachment was used in the stoma and worked very satisfactorily (Fig. 11). The patient was up and about and enjoyed his food by mouth. Suddenly on April 14, 1938 the patient's temperature rose from normal to 102 degrees and pulse from 80 to 116. On April 16, 1938, left sided weakness developed, which within 6 hours became a total left sided hemiplegia. His neck became stiff shortly before death. The patient's pulse accelerated, his stupor increased, and the patient died at 5:00 p.m.

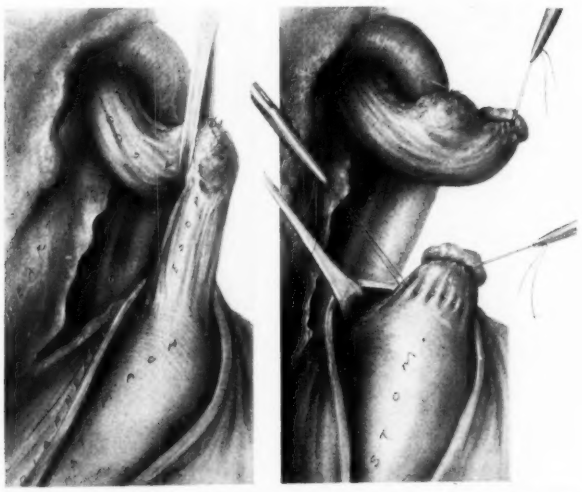


Fig. 5. The diaphragm has been opened widely and dissected free from the stomach and esophagus. Through this exposure it is possible to remove involved glands along the lesser curvature. Note that the pursestring suture has been placed in the stomach rather than in the esophagus.

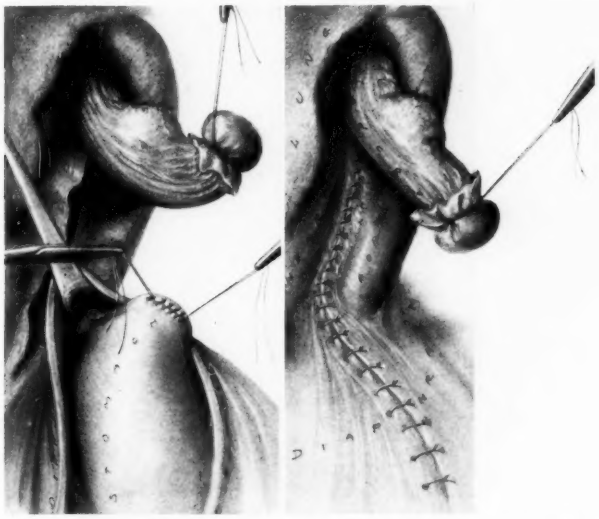


Fig. 6. The pursestring suture in the stomach has been inverted beneath Lembert sutures of silk. The diaphragm has been closed, as has the parietal pleura.

An autopsy was performed. Multiple small multilocular lung abscesses and areas of atelectasis were found in the left lung. An early lobular pneumonia and chronic pulmonary emphysema were noted. A small encapsulated empyema cavity was present in the left pleural cavity. A lymph node 2 centimeters in diameter was found at the cardiac end of the stomach on the lesser curvature, which on section showed carcinoma, but there was no evidence of any other metastases. The brain showed no abscess, but there was a well marked basilar meningitis with ependymitis.

The pleural cavity was not drained by means of catheters at the end of the operation. This was an error in judgment, especially in view of the

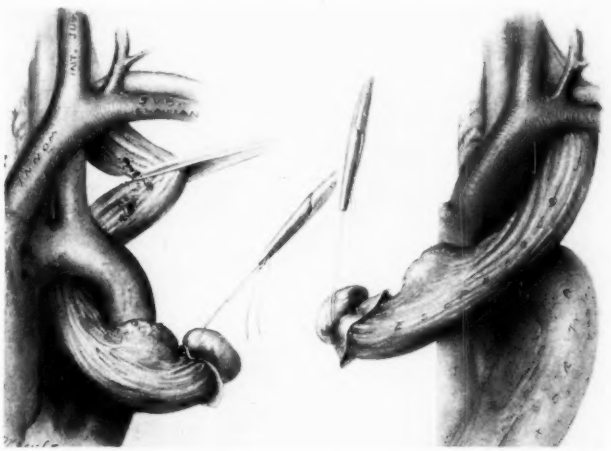


Fig. 7. The esophagus has been freed above the aortic arch up to the root of the neck and has been pulled up from behind the arch.

Fig. 8. a, left. An incision is being made in the suprasternal notch. Note the bulge in the notch which is caused by the finger within the thorax pressing the tissues forward. b, The esophagus has been pulled out through the incision in the suprasternal notch.

fact that soiling had occurred when the purse-string suture tore out of the esophagus. Drainage of the pleural cavity I believe, should always be done for it (1) removes (by constant suction attached to the catheters) the bloody fluid which acts as a good culture medium for bacteria and (2) promotes complete expansion of the lung.

The pursestring suture beneath which the distal stump of esophagus was inverted was placed in the esophagus rather than in the stomach. This should never be done for it is difficult to place the suture in the esophageal wall so that it will not tear out when the attempt is made to invert the esophagus into itself. If placed in the stomach the suture holds more firmly and it is much easier to invert the esophageal stump into the larger stomach rather than into itself. The soiling which resulted when the suture tore out was responsible for the empyema and for the wound infection.

The involved lymph gland near the hiatus on the lesser curvature of the stomach was missed largely because the diaphragm was not opened. It was the only site at autopsy in which metastasis was found and its removal, had the patient lived, would have made the difference between a possible cure and a certain failure.

Case 2. A. M., Cincinnati General Hospital No. 118195. A white man 53 years of age entered the hospital on March 7, 1939, complaining of inability to swallow. He first noted difficulty in swallowing 1 week before admission when, while eating an orange, he felt something stick in his gullet just beneath the sternum. There was moderate pain beneath the sternum and a feeling of fullness there also. During the week prior to admission he had been able to swallow only small portions of soft food and small amounts of liquids, and had lost 6 pounds in weight. The past history was negative except for chronic alcoholism and for lues of many years' duration.

The patient was a thin, weak man, appearing to be about 60 years of age. There was evidence of recent loss of weight. Mentally the patient was well oriented, but was dull and apathetic. His temperature was normal, his pulse was 80, and his blood pressure 135/80. There was nothing remarkable about the general physical examination. The Wassermann was positive.

Roentgenograms after ingestion of barium showed an obstruction in the esophagus at the level of the eighth dorsal vertebra. This obstruction seemed round in that the opaque meal appeared to pass around a circumscribed rounded mass. The roentgenologist suggested that the obstruction might be due to a bolus of food. However, esophagoscopy showed an ulcerated, thickened area in the mucous membrane of the esophagus 12½ centimeters from the incisor teeth and biopsy from this ulcer showed squamous cell carcinoma, grade 3. After esophagoscopy the patient could swallow easily and well and left the hospital saying he would return in a few days. He returned at the end of 3 weeks, having lost 10 pounds and being unable to swallow anything but small amounts of liquids.

On April 24, 1939, a Janeway gastrostomy was performed under local anesthesia. There were no palpable nodules in the liver but a small gland could be felt along the lesser curvature of the stomach near the esophageal hiatus. The gastrostomy functioned well and with frequent feedings of a high caloric diet and vitamins the patient gained 5 pounds in weight and improved in strength and appearance. A complete artificial pneumothorax was induced in the left pleural cavity.

On May 8, 1939, a portion of the thoracic esophagus was resected. Under cyclopropane anesthesia an incision was made along the course of the left seventh interspace from the nipple line to the posterior axillary line, where it was curved upward between the scapula and the spine to the third rib. This incision was deepened down to the pleura and 1 inch segments of the vertebral ends of the seventh, sixth, fifth, and fourth ribs were resected. The pleural cavity was entered in the seventh interspace, and the chest was spread widely with rib spreaders. A rounded tumor mass 4 centimeters long and 3 centimeters wide was found in the esophagus about 3.5 centimeters below the aortic arch. There were no enlarged glands in the mediastinum. The phrenic nerve was crushed and a long incision was made through the parietal pleura over the esophagus from the aortic arch to the esophageal hiatus in the diaphragm. By sharp and blunt dissection the esophagus was freed from the diaphragm to the lower limits of the tumor. The esophagus was similarly freed from the aortic arch to the upper limits of the tumor and tapes were passed about the

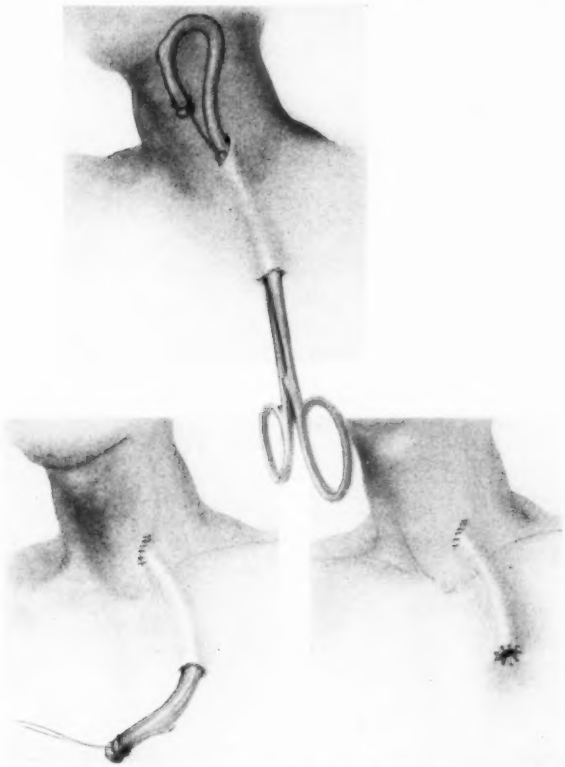


Fig. 9. A short transverse incision has been made in the second interspace (higher if necessary) and a tunnel formed communicating with the neck incision. The esophagus is drawn through this tunnel, the tumor amputated with a good margin, and the edge of the esophagus sewed to the skin.

esophagus above and below the tumor. The tumor was adherent to the aorta but not densely so and by sharp dissection was freed from it.

The diaphragm was widely opened from the esophageal hiatus laterally for about 4 inches and freed from the stomach and the esophagus. One small hard gland was found on the lesser curvature close to the esophageal hiatus. This was removed. A pursestring suture of silk was placed around the cardiac end of the stomach just below its junction with the esophagus. The esophagus was divided between pursestrings of silk just before it entered the stomach. The lower end of the esophagus was inverted into the stomach beneath the pursestring and the latter was inverted beneath four Lembert sutures of silk. The lower end of the remaining upper portion of the esophagus was covered with a piece of rubber dam which was tied tightly with a piece of braided silk.

The esophagus was freed from beneath the aortic arch, where it was necessary to ligate two large vessels which entered the esophagus. The vagus nerves could be dissected off the tumor and the esophagus, only a few small branches having to be sacrificed. The esophagus was then freed by blunt dissection up to the level of the suprasternal notch. The operator's left hand was placed within the thorax and the index finger was pushed into the suprasternal notch. Within the right hand an incision 2 inches long was made over this finger in the notch, and a curved clamp was introduced through the incision down into the thorax. The braided silk ligature on the end of the esophagus was grasped with the clamp and the esophagus with the tumor attached pulled out through the neck incision.

The thorax was closed with 3 kangaroo tendon pericostal sutures, a continuous suture of catgut in the muscles, and interrupted silk sutures in the skin. Two mushroom catheters were introduced into the chest before it was closed, one in the sixth interspace in the nipple line and one in the eighth interspace in the midaxillary line. After the wound had been closed the left lung was completely inflated, and the catheters were clamped off. A short transverse incision was made at the level of the second interspace close to the left border of the sternum, and a subcutaneous tunnel was made up to the neck incision. Through this tunnel the esophagus and tumor were drawn. The esophagus was now divided well above the tumor, and

Fig. 10. a, left. Intratracheal catheter with balloon deflated. b, Intratracheal catheter with balloon inflated.

its edges were united to the skin edges with interrupted silk.

The operation lasted 2½ hours. During the procedure a transfusion of 500 cubic centimeters of blood was given, and a second 500 cubic centimeters of blood was given at the completion of the operation. The patient's condition was good throughout the procedure.

The gross specimen consisted of a segment of the esophagus 12 centimeters long, containing an ulcerated tumor which extended around two-thirds of the circumference of the esophagus and for a distance of 8 centimeters in its long axis. The microscopic picture was identical with that of the biopsy.

The convalescence was smooth, all the wounds healing *per primam*. There was little drainage from the catheters for the first week, at which time the anterior one was removed. After a few days the remaining catheter began to drain thick fluid which on culture showed staphylococcus aureus and streptococcus. Drainage of this purulent material continued for 1 month after operation, at which time there was no empyema cavity remaining.

For many weeks the patient was most unco-operative and refused food through the gastrostomy on many occasions with the result that he failed to gain in weight and strength. Finally in October, 1939, he began to show a renewed interest in life and from that time on has gained 25 pounds and looks now very well.

At first the intratracheal tube with balloon attachment was used in the esophageal fistula. Later on a mushroom catheter cut off as in Figure 12 was used. This caused an area of skin slough and had to be discontinued for several weeks, all feedings being taken through the gastrostomy opening.

In November, 1939, an antethoracic skin tube was begun to join the esophageal fistula with the gastrostomy. This is being done in stages and is nearly complete. Its completion was delayed by the necrosis due to the mushroom catheter and to the appearance of a nodule about 1.5 centi-

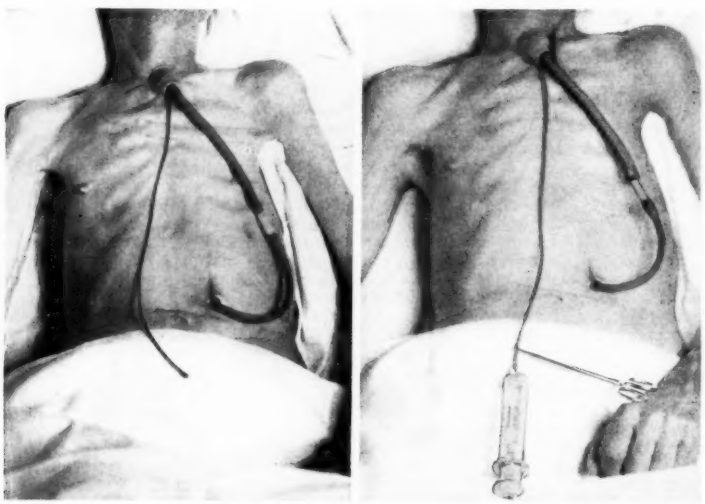


Fig. 11. Case 1. April 16, 1938. a, left. Intratracheal catheter in stoma and attached to gastrostomy tube. The balloon is deflated. b, The balloon inflated.

meters in diameter in the subcutaneous tissue about 1 centimeter proximal to the mouth of the esophageal stoma. This was felt to be carcinoma and proved so on biopsy, so in March, 1940 (10 months after operation) the lower 2 inches of the upper stump of esophagus were resected and the stoma moved upward for that distance. One other small subcutaneous nodule was removed along with the resected portion of the esophagus. It is hoped that the skin tube can be completed within the next 6 weeks.

The small empyema which occurred did not appear until 10 days after operation and may have resulted from leaving the drainage catheter in the thorax too long after operation. Cultures of the aspirated fluid did not show any organisms for the first week after operation. All the wounds healed *per primam*.

The occurrence of the two small nodules of carcinoma in the subcutaneous tissue near the stoma in the second interspace 10 months after operation was most probably due to implants of carcinoma which occurred when the esophagus with the tumor attached was pulled through the subcutaneous tunnel. In the future it is planned to resect the tumor bearing area with a good margin before the esophageal stump is pulled through the subcutaneous tunnel.

By making a wide opening in the diaphragm a small involved gland was removed from the lesser curvature and also a good inversion of the lower esophageal stump with the stomach could be attained without soiling, due to the purse-string suture having been placed well down on the stomach.

A frequent site of glandular metastasis in carcinoma of the esophagus is the glands along the lesser curvature of the stomach close to the esophageal hiatus. These glands may be palpable at the time the preliminary gastrostomy is done but if they are not fixed their presence should not be a contra-indication to the resection of the esophagus. Their removal, however, if this is feasible, is essential to the cure of the carcinoma of the esophagus. The resection of these glands by the transabdominal route through which the gastrostomy is done is very difficult and well-nigh impossible. However, one has ready access to them through the diaphragm at the time the transthoracic resection of the esophagus is being done. We have had this experience in 2 cases in which esophagogastrostomy has been done for cancer of the lower esophagus. It would seem logical, therefore, that one should open the diaphragm widely at the time the Torek resection is being done, free the lower esophagus and cardia, and remove any glands which are present along the lesser curvature. This opening of the diaphragm to obtain this exposure gives one an opportunity to place the pursestring suture, through which the lower stump of the esophagus is inverted, into the firm stomach wall, where it holds much better than if placed in the more friable tissue at the junction of stomach and esophagus. Failure to place this pursestring suture in firm stomach wall resulted in its tearing out in our Case 1 and in soiling which was responsible for the subsequent empyema.

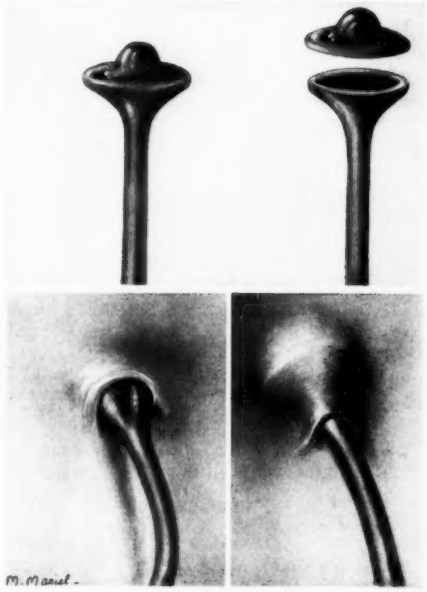


Fig. 12. The end of a mushroom catheter has been cut off and the folded catheter introduced into the esophageal stoma. The end of the catheter then unfolds itself and gives a snugly fitting tube.

In both cases reported here Torek's original technique was used in dealing with the upper stump of the esophagus. He freed the esophagus up to the root of the neck from within the thorax and then made a short incision to the left of the suprasternal notch, through which he pulled the esophageal stump. This procedure seems preferable to making an anatomical dissection of the esophagus in the neck through a cervical incision for it is less time consuming and what is more important, it does not interfere so much with the blood supply to the freed esophagus. The blood supply to the upper end of the esophagus was excellent in both of our cases, and healing without infection took place rapidly between the skin and the esophageal mucous membrane.

The management of the esophageal fistula which results from the open end of the remaining esophagus may be very troublesome. The chief difficulty which has been encountered in the 2 cases herewith reported has been leakage of saliva and food around the tube which has been placed in the open end of the esophagus and by which this open end is joined to the gastrostomy opening. This leakage is especially liable to occur in the first few weeks after operation, for at this time there is little contracture of the tissues surrounding the fistulous opening, and as a result there is no constriction present which will hold a tube and prevent leakage. It is well known that as soon as the patients begin to swallow saliva they begin to improve and gain in weight. Consequently any means which will promote the early swallowing of food and saliva without leakage is very helpful in the postoperative care. With this in mind we have introduced an intratracheal catheter with a balloon attachment into the esophageal fistula and gently inflated the balloon (Figs. 10 and 11). This gives a snugly fitting indwelling tube about which there is little leakage and which may be left in place for many hours without the danger of pressure necrosis. The disadvantage of the balloons is that they are rather delicate, soon wear out, and are expensive to replace. We have attempted to have sturdier ones made, but thus far have been unsuccessful, largely through lack of interest of the manufacturers. Later in the patient's convalescence when scarring and contraction of the mouth of the fistula have occurred we have used a mushroom catheter, cut off as shown in Figure 12. This works very well, but it must be changed and the skin watched for pressure necrosis which occurred in one of our cases, due to the introduction of too large a mushroom.

The Torek operation combined with the removal of the lymph glands along the lesser curvature appears to be the procedure by which the carcinoma of the esophagus can be most completely and thoroughly removed. A wide margin can be given to the tumor and local recurrence should not occur. It would seem to be the operation of choice for tumors of the intrathoracic esophagus, occurring anywhere from just within the thorax down to the lower one-third. For the cancers of the lower one-third of the esophagus a resection of the growth and the performance of an esophagogastrostomy is most ideal. The danger of the esophagogastrostomy, however, is that one may be so anxious to perform it that an insufficient length of esophagus is resected and local recurrence will take place. Unless a satisfactory margin can be given the growth, i.e. at least an inch and a half above the upper limits of the tumor, it is safer to abandon the idea of an esophagogastrostomy and perform the Torek operation. Although the stomach can be mobilized and brought high up into the thorax, the technical difficulties of performing the anastomosis beneath the aortic arch are so great as to preclude its performance.

SUMMARY

1. Two cases of carcinoma of the middle third of the esophagus treated by resection according to Torek's method are reported.

2. A wide incision through the diaphragm in order to remove involved glands along the lesser curvature and to permit a satisfactory inversion of the distal stump of the esophagus into the stomach is advocated.

3. A method of dealing with the esophageal fistula is given.

4. For the complete removal of the majority of carcinomas of the thoracic esophagus, the Torek procedure is the most satisfactory. Esophagogastrostomy finds its greatest field of usefulness in the treatment of carcinoma of the cardiac end of the stomach or of carcinoma in the terminal esophagus.

A HEAD INJURY SURVEY

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THE case records of patients admitted to the Los Angeles County Hospital with a head injury problem during the 6 years from July, 1928, to July, 1934, have been reviewed. The important points from the consequent statistical tables are here presented as a gross summary. More detailed accounts of individual cases and groups of cases have been and will be used in other papers.

There were 5,912 cases. Major cases, 1,969, or 33.3 per cent, comprise all those with definite cerebral damage with or without skull fracture, all cases with skull fracture, and all cases which developed complications. Minor cases, 3,943, or 66.6 per cent, were those with little evidence of brain injury and no skull fracture. Of the major cases 546, or 9.2 per cent of the total, 27.7 per cent of the majors, were so classified because of skull fracture only, as there was no apparent serious brain injury. These and the minor cases, totaling 4,489, or 75.8 per cent, required only bed rest and general care. The 1,423 remaining, or 24.2 per cent, are those in which a brain injury was evident, or which developed complications or required operation.

The fact that 75.8 per cent of all head injury patients recover without special treatment gives a false sense of security, tending to throw the other 24.2 per cent into a class of cases in which the results, either death or disability, are accepted as a matter of course, and therefore a number of cases in the smaller group which might be saved are overlooked.

Deaths. There were 445 deaths, 7.5 per cent of the total and 22.6 per cent of the majors.

Age. The average age for the major cases was 33.13 years; for the minors 33.5 years. Age has been charted against all injuries and all deaths. By comparing the two charts in Figure 1 the number of deaths for each age can be seen. The highest number of deaths—22—for an age is seen at 50 years. The injury chart shows 101 cases at that age, thus a 21.5 per cent death rate. At age 21 there are 6 deaths in 149 cases, a 4 per cent rate for that age. Ratio of death is thus shown for each age.

Manner of injury. Figure 2 shows manner of injury and the etiological factors related to age. In this chart each co-ordinate in the horizontal line represents one year. The height of the column in each instance represents the number of cases in that age. The co-ordinates left unfilled, which show themselves as indentations from the base line, are the number of each age recorded as suffering from acute alcoholism. In "auto-pedestrian" and in "falls" one finds the result of the carelessness of immaturity and that of old age. In "assaults" and "auto-collisions" one finds the result of the carelessness of vitality. Attention is called to the pairing of these chartings.

The total number of automobile accidents was 3,604 or 61 per cent of all cases. Falls accounted for 940, or 15.92 per cent; assaults, 687, or 11.63 per cent; miscellaneous causes, 242 or 4.1 per cent; motorcycle accidents, 110 or 1.86 per cent; and in 323 cases, or 5.4 per cent, there was no history.

Manner of injury and death. The death rate of "auto-pedestrian" was 9.1 per cent and "falls" 9.5 per cent. These were high compared with a 6.3 per cent rate for auto collisions. Auto-pedestrian and fall injuries occur more frequently among the aged and the immature, and the aged especially, when injured, are less likely to recover. Also, the mechanism of brain injury in a fall or auto-pedestrian accident has a greater component of the "head-movement-suddenly-stopped" factor (5).

Hospital days. The average hospital stay for all cases was 13 days: for major cases, 16 days, and for minor cases, 11.4 days. The longest stay among the major cases was 289 days (complications): the shortest 1 day (death). In the minor cases the longest stay was 270 days (other injuries): the shortest 1 day (patients who left without consent or transferred to other hospitals).

Many of the patients left of their own accord after signing a release of responsibility, and complete follow-ups were not obtained. To be perfectly safe in any head injury case, even without apparent serious brain damage, a 14 day bed rest period should be required. The averages found are the desirable basic requirements in treatment (14, 24).

Hospital days and infection. There were 20 cases of scalp infection and 6 of these had osteomyelitis. The average of hospital days for these

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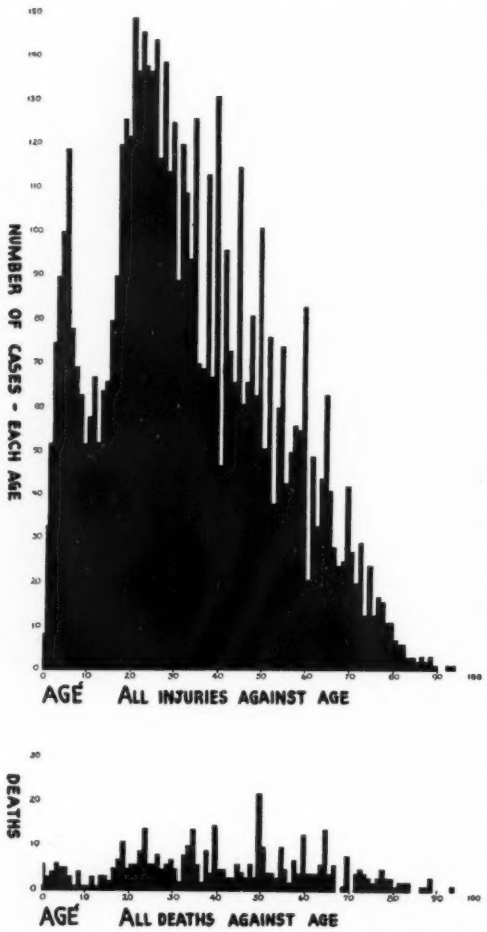

Fig. 1. Comparison of number of injuries and deaths for each age.

infections was 49. The structure of the scalp is such that the wounds most often appear as lacerations which, when sutured, should heal *per primam*. However, scalp bleeding is so severe that suturing is often done without adequate cleansing underneath. Several cases of scalp infection when reopened for examination or elevation of a depressed skull fracture showed hair and foreign substances which were exposed only when the original laceration was enlarged. These cases caused our longest periods of hospitalization.

Hospital days and death. Of the deaths 51.7 per cent occurred on the first day; 79 per cent had occurred by the fifth day; 90.4 per cent by the eleventh day. It is strongly felt that movement reduces the chances of recovery (6, 13), as do also extensive emergency repairs. A number of cases were found in which the condition might not have become so serious had the patients been kept absolutely quiet after the accident, and movement to both emergency station and general hospital delayed. A high percentage of first day deaths is undoubtedly caused by the original injury, but the reactions to the injury are probably responsible for an equally high number and these reactions are increased by movement, administration of fluids, and surgical procedures.

Unconsciousness. There were 2,979 patients unconscious, or 50.3 per cent of 5912. Of these 1,040 were major cases or 52.9 per cent of 1969. In a large number of cases the duration of unconsciousness was not stated, "short" and "long" being as nearly accurate as circumstances allowed. Unconsciousness carried a death rate of 28.5 per cent: "time not stated," 45 per cent: "short time" 3.9 per cent: "long time" 50 per cent: "intervals" 71 per cent. Under unconsciousness of one day the death rate was 79.8 per cent. These deaths undoubtedly include all of the cases in which death occurred on the first day. The figures concerning minutes and hours are too complicated for this gross summary.

In the semiconscious cases the death rate was 17.8 per cent as compared with a rate of 28.5 for unconscious patients. In "time not stated" there is a 20.6 per cent death rate as compared to a 45 per cent rate for unconscious patients. The few labeled "short" among the semiconscious carried no death rate as compared with a 3.9 per cent rate for "short" unconscious patients.

The combined unconscious and semiconscious data indicated that an unconscious patient who awakens to a rational state has a much better chance for recovery than one who awakens to semiconsciousness.

Unconsciousness is believed to indicate the severity of the injury in direct ratio to its time; that is, a long period of unconsciousness a very severe injury, and vice versa. The following facts question this general belief. One patient (automobile collision) walked into the emergency station, became unconscious several hours later, and died the next day from a severe contusion and laceration of the brain. Another patient, after a very mild injury, became unconscious on the third day from a large extradural hematoma. There were 8 major cases recorded as not having been unconscious, and these indicate that the state of consciousness upon the first examination

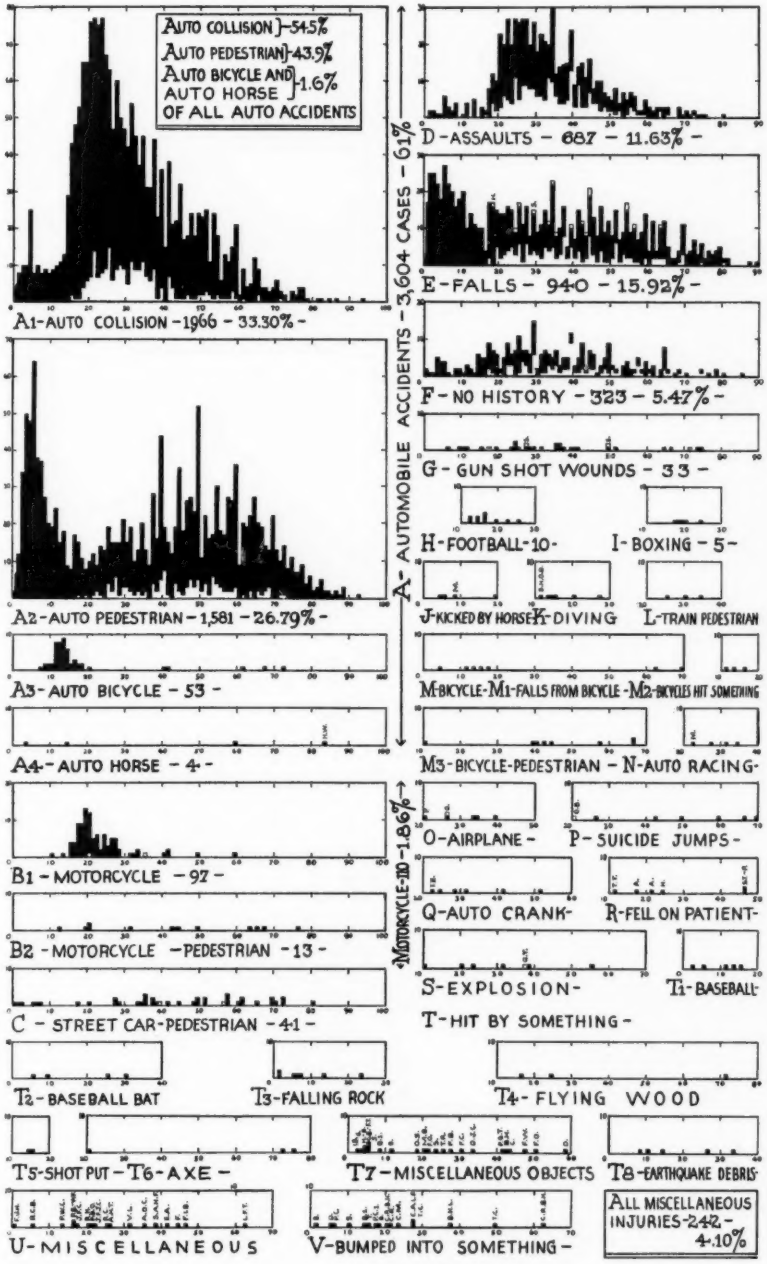

Fig. 2. Age against manner of injury.

is not a good criterion of the extent of injury. Short periods of unconsciousness or no unconsciousness do not warrant relaxation of vigilance.

Objective evidence. Some form of external abrasion, laceration, or contusion was present in 5,415, or 91.6 per cent, there being 497, or 8.4 per cent without external signs. Of the major cases 147, or 7.4 per cent, showed no external evidence of injury, while among the minors 350, or 8.9 per cent, were without objective signs.

Although the absence of objective evidence of injury is very low, nevertheless it must be taken into consideration that 7.4 per cent of the seriously hurt head injury patients will show no external evidence of injury. When confronted with an unconscious patient with no history, possibly a person who has been drinking, this is important. At least one such patient in this series died, a head injury not having been suspected as it was completely masked by no external evidence and superimposed alcoholism. There are, perhaps, more such cases than we realize (1).

When ecchymosis of the eyelids is present, especially without local injury at that point, there is always a question of basal skull fracture. This is also true with blood from the nose, blood from the ear, blood from the mouth, and spinal fluid from ear, nose, or mouth, and ecchymosis of the mastoid regions. Spinal fluid from ear and nose was the only external evidence confined to the major cases. All of the other significant external evidences were present in minor as well as major cases, but the percentages in the major cases were greater. As examples, blood from ear, majors, 20.6 per cent; minor, 5 per cent; blood from nose, majors, 18.3 per cent; minors, 7.5 per cent; ecchymosis of eyes, majors, 31.5 per cent; minors, 17.5 per cent.

Subjective evidence. Patients with subjective evidence totaled 1,662, or 28.1 per cent. The percentage of recorded subjective evidence in both major, 568 cases or 28.7 per cent, and minor cases, 1,094 or 27.8 per cent, was approximately the same, indicating that subjective evidence must be very carefully evaluated before it is given consideration in estimating the degree of injury.

Roentgen-ray examination. Roentgen-ray examination was made on 5,136 patients, or 86.9 per cent. In 14.1 per cent of the major cases and 12.6 per cent of the minor cases no such examination was made. Death prevented such examination in 208 of the major cases; in 46 cases no reason was given, the conclusion being that these patients were not co-operative; 18 were transferred to other hospitals; 2 were demented; 4 had a question mark on the record. The 476 minor cases not subjected to x-ray examination, and 21 without reports, were undoubtedly patients whose condition was satisfactory and recovery rapid.

Skull fracture. There were 1,362 proved skull fractures in 1,969 major cases, a 69.2 per cent proved skull fracture incidence in severely injured patients. Of these 1,362 cases, 1,071 were proved by x-ray and 291 confirmed at postmortem examination or at operation. There were 289 major cases in which there was no skull fracture upon roentgen-ray examination, and skull fracture was not diagnosed by clinical evidence. In addition to this there were 314 cases in which basal skull fracture was diagnosed but not proved. Proved at autopsy, proved by x-ray, not proved but diagnosed clinically gave a total skull abnormality in 1,680, or 28.5 per cent of the total and 85.2 per cent of the majors. No skull abnormality was present in 4,232, or 71.1 per cent, of the total, and in 289, or 14.7 per cent, of the majors.

Considerable separation in the continuity of the skull can take place with injury which may resolve itself so completely that it cannot be demonstrated by roentgen-ray. This was illustrated by 10 cases of vault fracture and 28 cases of base and vault fracture which were not seen in the roentgenograms but were proved at autopsy. A basal skull fracture without x-ray evidence is not unusual. There were 92 other cases upon which roentgenograms were taken and skull fractures not seen, in which basal skull fracture was proved at postmortem examination. *These facts show that a negative skull set of films does not exclude fracture.*

Skull fracture of itself is not a cause of death (2, 5, 10, 32). It is the hemorrhage, contusion, and concussion accompanying the trauma which has caused the skull fracture and the consequent reactions to this injury that are responsible for death. This is dependent upon the mechanism of injury (5). As an example, one of the patients in this series was brought to the hospital with a very severe basal and vault fracture after having a piano fall upon his head. The patient made an uneventful recovery and the case was analogous to the cracking of an eggshell without injury to the contents. The 546 patients with skull fracture only, and recovering without special treatment were cases which illustrate such conditions. If skull fracture is present the probability is that the brain injury is more severe. However, this is by no means a rule.

Eye abnormalities. There were 512 patients with eye abnormalities, or 8.66 per cent. Of these 361, or 18.35 per cent, were major cases and 151,

or 3.83 per cent, were minor cases. Inequality of the pupil was the most frequent finding. In diagnosis of massive hemorrhage a dilated pupil is of great value. However, its absence does not rule out massive hemorrhage (2, 9, 10, 15, 32). Pressure discs with acute head injuries are seldom found. The absence of pressure discs does not exclude massive hemorrhage. There was one case in this series with unilateral blindness which was relieved by release of pressure by spinal puncture. Incidences of nystagmus, deviation, ptosis, fixation, were few.

All eye signs are of the greatest importance and occasionally are very difficult to explain, as they may be evidences of destruction or irritation of nervous tissue, or pressure. It should be remembered that more than one explanation of an abnormal eye finding can be given, and that to estimate the localization and character of a lesion all of the possible explanations must be considered.

Reflexes. Patients with abnormalities numbered 513, or 8.67 per cent. Of these 367, or 18.65 per cent, were major cases, and 146, or 3.7 per cent were minor cases. Reflex findings depend upon the time after the injury at which the examination is made. During the period of shock the severity of the brain injury is difficult to diagnose. Often there is a physiological ablation of cortical influence, and there may be a complete absence of reflexes or no change whatever. As shock passes away and the brain adjusts itself to the injury, reflexes return and paralyses manifest themselves and may run the course of spasticity to flaccidity, or vice versa.

In several cases notes by one observer showed reflex changes and by another showed a discrepancy in the findings. Reflexes alter as the pathological condition progresses or regresses, and these discrepancies were due to this. The various reflex findings may be present in both major and minor cases, but in cases of severe injury the percentage is much higher. Reflex changes and eye changes run about the same percentage and are approximately paralleled by the number of pathological plantar responses. Incidences of spasticity, paralysis, clonus, convulsions, were small in comparison. Stiff neck was present in 360 cases, and 245 of these were from the major case group. Excluding the meningitis cases, these were presumed to be due to subarachnoid bleeding.

There were 24 cases of peripheral facial palsy, an incidence of 0.4 per cent of the total, 5,912; 1.2 per cent of the majors, 1,969. The time of onset was from 1 to 7 days after the injury. The later onsets were probably due to edema of the facial nerve, the earlier ones to basal skull fracture with injury to the nerve. Complete follow-up records on these cases were not present. However, all were recorded upon subsequent entries as recovered. Some of the recoveries took place before discharge. One patient with peripheral palsy died of meningitis.

Pulse. A careful watch of the pulse rate is one of the most important procedures in the care of cerebral injury. Many slow pulses would be caught in a 15 minute pulse charting that are overlooked in a 4-hour charting. Slow pulse rates indicate attempt at compensation to pressure from edema, or massive hemorrhage. The pulse of shock is rapid and weak; the pulse of edema is slow and full; the pulse of medullary compression or decompensation variable, changing from fast, weak, and irregular to slow, strong, and regular. These changes may occur within a few minutes.

With compensation taking place the majority of patients ran a slow pulse for their age. The relation between age and pulse rate must be considered with children especially, as a comparatively slow pulse for infancy might be a rapid one for maturity. With general decompensation to pressure or the complications of infection a rise in the pulse rate took place. In one case, during fluid restriction regimen, the rapid pulse rate of toxic dehydration simulated the rapid pulse rate of pressure decompensation. One other form of slow pulse rate that should not be confused with edema is that caused by sedatives.

Respiration. Respiration is rapid during shock and slow during periods of edema. It varies in direct relation to the pulse rate, and for the same reasons. In this series Cheyne-Stokes respiration was found in others as well as in terminal cases. It is usually considered as a sign of medullary compression and is a warning of cerebral decompensation. However, it may be present with dehydration. The effects of sedatives can give an alarming picture, with Cheyne-Stokes respiration and a slow pulse. A careful watch of the respiration is concomitant and ranks equally in importance with the careful watch of the pulse.

Blood pressure. Just as the pulse was usually slow for the age with a compensating brain, the blood pressure was usually slightly elevated. There were many cases in which a slow pulse indicated edema, in which the blood pressure seemed normal, and there were other cases with a rapid pulse due to dehydration with no apparent alteration in the blood pressure. The diastolic pressure in some cases was very low. During decompensation the blood pressure rises until the break preceding death. In the majority of cases the constancy of the blood pressure was remarkable.

Temperature. There was a mild rise in temperature in almost every case after the subnormal temperature of shock had ceased. In children the rise was marked. In fatal cases the temperature rose with decompensation, and the patients approached death with hyperthermia, in some cases the temperature ranging as high as 108 degrees. As a patient recovered the slightly raised temperature returned to normal. However, it also returned to normal in some cases which did not recover but in which the compensation for the time being was excellent. In one case a pressure temperature due to subdural hematoma was mistaken for that of bronchopneumonia, and it is obvious that this temperature rise was an early decompensation indication, with hypostatic pneumonia developing. Temperature may be altered upward by intensive dehydration; by transfusion reactions; by injury to the temperature-regulating centers; and, secondarily, by pressure.

It is quite natural to regard definite objective evidences such as external injuries, roentgen-ray findings, state of consciousness, as the most important factors in diagnosis. The external manifestations of physiological changes within indicate what is happening to a brain which we cannot examine. Therefore, changes in the reflexes, temperature, pulse, respiration, and blood pressure are our most important aids (4, 35).

TREATMENT

In the treatment of acute head injuries several definite principles are recognized: absolute and prolonged rest; control of intracranial pressure; maintenance of tissue nourishment, both general and local. These purposes are accomplished by sedatives, non-interference, dehydration, lumbar puncture, intravenous hypertonic solutions, tube feedings, surgery. Each case is a law unto itself and may need one or all of these procedures (6, 13, 16, 17, 23, 26, 28, 29).

Medication. Intravenous glucose, 50 per cent, was the most common form of medication. It was administered in a total of 858 cases, or 14.5 per cent. It was used in 581, or 29.5 per cent, of the major cases. Hypertonic injections, intravenously, have been used for some years and their use has been defended by physiological research and by successes in treatment in various locales (3, 6, 7, 12, 13, 16, 17, 23, 26, 28, 29, 33). Faith in this method of reducing increased intracranial pressure is at present waning.

Thirty-three patients showed sugar in the urine. The question arose whether or not this was due to the administration of glucose or to an upset in the sugar metabolism due to a blow on the head. A generalized concussion can cause a change in the sugar metabolism and a discharge of sugar into the urine.

Glucose in normal saline solution, intravenously, was used infrequently. Restriction of fluids was used in a very small number of cases. There were 113 patients who received normal salt intravenously. The administration of fluids in head injury cases is a matter of controversy (8, 11), and there is a difference of opinion among authorities.

Many patients received morphine at the emergency station. With the logical arguments against it and the general feeling of neurosurgeons that morphine is dangerous, it should not be used (3). Urotropine was administered intravenously for suspected meningitis. One patient with meningitis recovered and the recovery was attributed to this treatment. Sulfanilamide, and its associated compounds, is now used. Various other forms of medication were used for sedation, stimulation, and dehydration, and the percentages were small. The treatment in this series was of a conservative nature and depended in a great part upon non-interference and rest. These should be the basic requirements (6)

Spinal puncture. Spinal puncture embraces both treatment and diagnosis. A total of 832 patients received this treatment, 14.1 per cent: 613 of these or 31.1 per cent were major and 221 or 5.6 per cent were minor cases. There were cases of recovery and of death with almost every combination of pressure and appearance. For instance, normal pressure, normal appearance, 167 cases, with a major death rate of 13.2 per cent; normal pressure, bloody, 117 cases, death rate 31.7 per cent; low pressure, bloody, 19 cases, death rate 46.7 per cent; high pressure, yellow, 29 cases, death rate 33 per cent. Of the cases with spinal fluid of high pressure, normal appearance the majority were in the minor group, there being only 3 deaths in the major group. With a pressure above 300 millimeters and normal appearance the majority of cases fell into the major group and the death rate was greatly increased. Among those with high pressure and changed appearance, the death rate was high. However, there was one case with a pressure of 500 millimeters and bloody fluid and the patient recovered.

Many patients receiving spinal punctures died. This does not mean that spinal punctures are contra-indicated but merely that spinal puncture is more likely to be done upon a patient whose condition is serious and who may die. Spinal drainage for treatment was carried out with success in several cases. It is a very effective method

of reducing increased intracranial pressure where there is no block in the ventricular system (18–22, 34).

Three incidents were recorded to which special attention is called: that of the blood pressure falling after spinal puncture; that of the regaining of consciousness after spinal puncture; and that of the pressure being high and falling after administration of intravenous glucose. These are all of importance. They show the pressure reduction after spinal puncture, and the third, especially, shows that a spinal fluid reading shortly after the injection of intravenous glucose is of little value in estimating the pressure in the brain.

Treatment with spinal puncture, hypertonic solution, and restriction of fluids may be greatly overdone (20–22). Hypertonic dextrose solution routinely administered without depletion of general bodily fluids causes increased edema and may cause death. Under a fluid restriction regimen, a patient can die from toxic dehydration, and in the use of any of these procedures for the reduction of increased intracranial pressure very careful watch of the reactions must be provided in order to avert the complications of the treatment as well as to judge its efficacy.

Operations. A total of 195 was carried out, 3.3 per cent, of 5912; 9.9 per cent of major cases, 1,969.

The value of operative interference in head injury recovery has often been questioned. It has as its purpose 2 things: the removal of massive hemorrhage, and the reduction of pressure by drainage of fluid (9, 15, 25, 31). In keeping with the general conservative management of this type of case the number of operations in this series was small. Elevations of depressed fragments, 103, comprised 52.8 per cent of the operations, with an 8.7 per cent death rate; subtemporal decompressions, 50 cases or 25.6 per cent, with a death rate of 36 per cent: extradural hematoma, 9 cases, or 4.6 per cent, with a death rate of 77.8 per cent; subdural hematomas, 18 cases, or 9.2 per cent, with a death rate of 22.2 per cent. In 15 cases, or 13 per cent of the operations, there was found massive fluid collection which was not diagnosed before operation. Only one patient died, a death rate of 6.6 per cent. Simple trephining of the skull was not done in these cases, a complete decompression operation having been performed once the patient was in the operating room. The use of subtemporal decompression has greatly decreased, trephining taking its place. The size of the area to be exposed in decompression is exceedingly small compared to the size of the area of the entire brain, and when the operation is successful it is because of the release of fluid from the subdural and subarachnoid spaces, and this can be accomplished through a trephine opening (9, 15, 25, 31). In cases with increased intracranial pressure a trephine opening, with release of subdural fluid, or decompression by means of ventricular drainage is a less hazardous procedure than even spinal puncture.

In one of the cases of extradural hematoma the clinical picture was classical, and bilateral subtemporal decompression, performed in a routine manner, failed to disclose the hematoma. At autopsy the large extradural hematoma which had been diagnosed was found 1 centimeter anterior to the site of operation. Exploration with multiple trephines would have located this hematoma (15).

COMPLICATIONS

The incidence of complications was taken from the postmortem records and percentages were figured only against each condition, as there was often more than one of these conditions in a single case.

Edema. It is assumed that a certain degree of edema takes place in every case and it is the factor in head injury work to which the treatment is most often directed. At autopsy, however, only 53 cases, or 2.6 per cent of the majors and 0.9 per cent of the total, showed this complication alone. No cases with other complications were without it.

Diffuse hemorrhage, contusion, laceration. The highest other complication was diffuse subdural hemorrhage, 213 cases, or 3.6 per cent of the total, 10.8 per cent of the major cases. Next highest was contusion, 103 cases, or 1.7 per cent of total, 5.2 per cent of the major cases. Contusions and lacerations of the brain, and subarachnoid hemorrhage were diagnosed in a number of patients who recovered and there was no proof that such complications were present. There were 9 patients with a history of old head injuries and 6 of these died, the presence of the previous injury being found at postmortem examination. There are also records of contusions shown at autopsy in patients who died of other causes. Thus the figures for most of these complications may be small compared to the number of these conditions that actually do exist and are not known accurately because of the recovery of the patient. Contusions and lacerations, if not in vital areas, need not cause the death of the patient, as we know that large portions of the brain may be destroyed without death.

Petechial hemorrhages, a very important complication, have unfortunately been omitted in the

numerical summary. They are frequent about contusions and lacerations, and in localized areas (5). Two reasons for their presence are possible: original injury; and capillary blocking in an area of most intense edema. The latter hypothesis is favored by me and is logically supported by the reactions which take place in injury.

Massive hemorrhage and fluid collections. There were 46 cases of massive subdural hemorrhage, or .75 per cent of the total, 2.3 per cent of the major cases. Fourteen of these recovered after surgery, thus leaving 32 deaths in which the result was due to the severity of the original injury, or in which the clinical evidence was not sufficient to warrant surgery. There were at least 10 patients who had been in the hospital more than 5 days—one of them as long as 60 days—in which there was shown at postmortem examination massive subdural hemorrhage. This fact makes it logical to suppose that had the space-occupying hemorrhage been discovered and released these patients might have recovered.

There were 38 patients, or .64 per cent of the total, 1.9 per cent of the major cases, with massive extradural hemorrhage, with 36 deaths. Of the patients who died 4 were in the hospital over 5 days, the longest stay being 9 days. The same conclusions were arrived at regarding massive extradural as massive subdural hemorrhage. Both extradural and subdural hematoma are of a rapid nature as regards mortality. They were often present in this series without the so called classic signs (2, 10, 32).

Subdural fluid collections numbered 23, or .39 per cent of the total, 1.2 per cent of the major cases. Eight were found at autopsy, 15 at surgery.

Infection. The incidence of otitis media was 19 cases, or .32 per cent of the total, 0.95 per cent of the major cases. Among the otitis media cases there were 2 deaths from meningitis, 1 on the eighth and 1 on the forty-third day. Five of these cases, including one of the deaths, were further complicated by mastoiditis. Otitis media as a complication of head injury was much more frequent in children, there being 12 patients under the age of 13. Seven other patients were adults, the oldest being 46, the youngest 17.

There were 33 meningitis cases, or .55 per cent of the total, 1.6 per cent of the major cases. One patient recovered. Five died on the first hospital day. These deaths were mostly in young patients, aged 1½, 7, 14, 19, and only 1 occurred in an adult, 50. Two died upon the third day, 2 upon the fourth, 4 upon the fifth, 2 upon the sixth, 1 upon the seventh, 4 upon the eighth day, 1 each of 11 patients on later days up to the forty-seventh, and 1 on the two-hundred-and-fortieth day. The onsets of meningitis were equally varied. The danger from meningitis is felt to be present after basal skull fracture for the time of 6 months, but it usually appears within 60 days.

One patient with a lung abscess developed a subdural abscess and it is felt that the head injury effected this complication of the lung abscess. There were 2 other cases of subdural abscess and 2 cases of brain abscess.

Thirty-six cases were complicated by pneumonia, and in the majority of these it was recorded as hypostatic; 1 was lobar and 9 were recorded as bronchopneumonia.

Six of the patients who remained in the hospital for a long time developed bed sores. Five of these died.

Miscellaneous. Any debilitating disease, such as tuberculosis or diabetes was noted to cause what ordinarily would have been a minor case to become a major one. Three patients who had tuberculosis died of minor head injuries. Others who died had angina pectoris, kidney disease, diabetes.

There were 109 cases in which the age of the patient was considered a factor in the death, and among these aged patients it was somewhat surprising to discover that 15 had massive subdural hemorrhage. This was an important finding, as an aged patient is often thought to be apoplectic, even though the history of injury is definite, and because of this he is seldom considered a proper subject for surgical treatment. Notes have been made that several of these aged patients might possibly have been saved by discovery and removal of the massive hemorrhage. Advanced age and head injury, regardless how minor, is a combination which always throws a case into the major group.

There were 2 patients with internal hydrocephalus resulting from the injury who died after a long period in the hospital. There were also 2 with pneumoventricle, 1 of whom died of meningitis. There were 3 cases that were probably complicated by the length of the emergency repair anesthetic. Anesthesia in itself increases edema of the brain, and with a brain that is at least potentially edematous it may assist in a reaction that will be fatal.

There were 9 cases of pre-injury psychosis, and this was partially responsible for the injury. There were 11 cases of pre-injury epilepsy and in these the epilepsy was a factor in the injury. Four of these patients died because of the head injury and a majority had epilepsy due to a previous head injury.

RESULTS

Of the total number of cases there was a 92.5 per cent recovery and a 7.5 per cent death rate; of the majors a 77.4 per cent recovery and a 22.6 per cent death rate. Of the recoveries, and from the major cases, there were 71 known posttraumatic mental disturbances (27, 30), and 2 known posttraumatic epilepsies. Many of these patients were originally discharged from the hospital as minor cases with recovery, but have been classified here among the major cases because of the sequelæ.

The follow-ups in this series are not good and these results are merely stated as being known, but may actually be very much higher in disability.

CONCLUSIONS

It is easy after a death has occurred and the pathological condition has been examined to say that had we been alert this life or that might possibly have been saved. However, it is difficult before death to make the decision and in many cases it can only be made upon probability. The largest number of patients died upon the first day and these undoubtedly were cases to which the classification of hopeless might be applied, that is, no matter what was done the outcome would be fatal. As has been mentioned earlier the danger lies in assuming that patients either recover or do not recover, and the throwing of 24 per cent of the total—the problem cases—into the hopeless class. Proper emergency and subsequent treatment will save more of these seriously injured patients.

A careful watch of the external manifestations of the physiological reactions within are the most important factors in the care of the patient. Other than absolute quiet there are no routine indications in treatment, and the tax upon the judgment of the attending surgeon is unceasing until recovery.

It has been implied that perhaps the greatest fault in emergency treatment is the movement of the patient and his transference from one hospital to another during the acute stage (6). It is felt that this movement entails enough stimulation to increase shock if shock is present, to increase bleeding if shock is not present, to increase to its maximum any reaction that may be taking place. Three patients who were apparently not seriously injured and who upon first examination at the emergency station were conscious and rational, later developed severe intracranial conditions after they disregarded the rule that absolute quiet was necessary. This emphasizes the probability of increase in complications due to movement of those who are obviously injured.

SUMMARY

1. A gross summation has been taken from a tabular statistical survey of 5,912 head injury case records.

2. Important incidences in etiology, treatment, and complications are enumerated and discussed.

3. The trend of present day treatment has been indicated by comment.

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FRACTURES IN THE REGION OF THE ELBOW IN CHILDREN
AN END-RESULT STUDY

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IT is generally accepted that the end-results of fractured elbows in children are good, even when the reduction is incomplete and normal alinement is not restored. The basis for this belief is that excellent function in the elbow is often compatible with gross misalinement, and we have become accustomed to expect good function following fractured elbows in children. Occasionally, however, we have a case in which the end-result is distinctly unsatisfactory both to the patient and to ourselves, and after a period of prolonged restriction of motion and poor function, the patient is left with a distorted elbow. We may have considered the initial injury quite minor, with a small fragment of bone detached, and yet this minor injury may have resulted in more disability than a much more severe fracture. Having seen this occur on numerous occasions, we decided to review the histories of all the fractured elbows in children that were treated on the Orthopedic Service of the Children's Hospital during the period of 1925–1935, and to study the end-results. It was hoped that data could be secured which would enable us to predict more accurately the outcome of the various types of fractures that occur in the region of the elbow in children and to determine if the optimism with which we disregard poor alinement could be justified.

This study concerns only fractures of the lower end of the humerus adjacent to the elbow. At a future date we hope to make a similar study of fractures of the upper end of the ulna and radius involving the elbow.

We have divided these fractures into three groups: supracondylar fractures; fractures of the external condyle and capitellum; and separations of the epiphyses of the medial epicondyle. Supracondylar fractures include diacondylar and transcondylar fractures, in fact, all transverse fractures of the lower end of the humerus within an inch of the elbow joint.

Fractures of the external condyle and capitellum are oblique intra-articular fractures and are so different clinically from the other varieties of elbow fractures that they must be considered as a separate group. Failure to appreciate this difference and treating this fracture like the supracondylar group can result only in disaster to the patient and discomfiture to the surgeon.

Separations of the epiphysis of the medial epicondyle are true epiphyseal separations, usually with no associated bone injury, and constitute a third clinical entity. They, too, must be treated on the basis of their own peculiar clinical characteristics, and no conclusions drawn from a study of the other two groups can be applied here.

There are 150 fractures in this series. One hundred are supracondylar, 36 external epicondylar and capitellum fractures, and 14 separations of the medial epicondylar epiphysis. Complete follow-up studies are available on 28 supracondylar fractures, 10 fractures of the external epicondyle and capitellum, and 12 separations of the medial epicondylar epiphysis—a total of 50 follow-up examinations.

RECENT SUPRACONDYLAR FRACTURES

In this series of 150 fractured elbows, 100 may be classified as supracondylar—most of them being recent acute fractures. Of 50 fractured elbows in patients who returned for follow-up, 25 were acute supracondylar when first seen, and 3 were old supracondylar fractures.

These children ranged in age from 2 to 10 years and were equally divided between the sexes. Nine fractures were incomplete with little or no displacement. The remaining fractures were complete with posterior, and either lateral or medial displacement of the distal fragment.

The number of years that elapsed since the original injury varied between 3 and 15. No follow-up cases are included in this series in which less than 3 years had elapsed since the time of the original injury.

The end-results from both a functional and anatomical point of view were evaluated in every case on the basis of the following outline in which the normal elbow was used as a standard for comparison:

Normal—indistinguishable from the opposite elbow by physical and x-ray examination.

Excellent—essentially normal when viewed alone but showing slight abnormalities when compared with the opposite elbow.

From the Orthopedic Service of the Children's Hospital.

Fig. 1.

Fig. 2.

Fig. 1. Case 1, F. W. Lateral view of left elbow showing a supracondylar fracture of 5 days' duration with poor reduction.
Fig. 2. Case 1. Same elbow 4 years later showing bone block preventing complete extension.

Good—no serious alteration in structure or function but obviously not normal even when viewed alone.

Fair—definite defect in structure and function but no serious disability.

Poor—serious disability due to poor function and structure.

When the end-results of the supracondylar fractures were evaluated, we found with one exception that they were all good to normal. This patient had a compound fracture which had been treated by an outside physician by a closed reduction and the child had been referred to the Children's Hospital 5 days later, with the arm immobilized in a plaster splint. X-ray examination revealed that the fracture was incompletely reduced, the lower fragment being still posterior and slightly lateral, and the upper fragment rotated. Because this was a compound fracture, it was felt inadvisable to manipulate it further, and fixation in the posterior splint was continued for 4 weeks, following which the splint was removed and physiotherapy was started. Two years after the initial injury, there was a permanent flexion deformity of 20 degrees. This degree of deformity was also present at the follow-up examination 4 years after the injury. This deformity in no way interfered with function of the elbow and caused no disability. X-ray examination taken 4 years after the initial injury showed the lower portion

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 3. Case 2, K. K. Complete supracondylar fracture of the left elbow: a, anteroposterior, and, b, lateral views.
Fig. 4. Case 2. Postreduction roentgenogram made 12 days later showing that fracture has slipped posteriorly.
Fig. 5. Case 2. Follow-up roentgenogram 10 years after injury showing normal elbow.

Fig. 6. Case 3, R. B. End-result of supracondylar fracture 2 years previously showing marked cubitus varus deformity with reduction of carrying angle secondary to growth changes in the epiphysis of the lower end of the humerus.

of the humerus to be still posterior, probably producing a bone block and preventing complete extension of the elbow. The roentgenograms of this patient's elbow are shown in Figures 1 and 2.

There were 6 fractures in this series in which the postreduction films were considered unsatisfactory. All of these went on to normal or excellent end-results with the exception of the one case already noted. The roentgenograms of one of these cases are shown to illustrate the restoration of normal relationships in spite of a poor reduction. This boy of 7 sustained a left supracondylar fracture which was treated by a closed reduction at the Children's Hospital. Immediate postreduction x-ray films were considered satisfactory, but check-up examination 12 days later showed

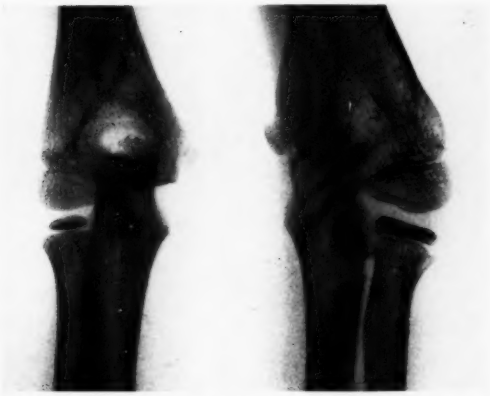

Fig. 7. Case 3. Roentgenogram showing overgrowth of external epicondyle following supracondylar fracture.

Fig. 8.

Fig. 8. Case 4, G. M. Fracture of left external epicondyle and capitellum with typical posterior and lateral displacement of the distal fragment—one of the most treacherous fractures of elbow in children. Open reduction would have been the best treatment. Closed reduction.

Fig. 9.

Fig. 9. Case 4. End-result 8 years later. Non-union.

Fig. 10.

Fig. 10. Case 5, V. L. Fractured external epicondyle and capitellum with typical displacement.

Fig. 11.

Fig. 11. Case 5. Thirteen years after open reduction. Child now has normal elbow.

the distal fragment again to have slipped posteriorly. No attempt was made to correct this second displacement, and on examination 10 years later, the x-ray revealed normal bone structures.

In spite of the excellent functional results obtained in these supracondylar fractures, very careful measurements of the carrying angles of both the normal and the injured elbows revealed definite alteration in the angles of the injured as compared to the normal elbow, even though many years had elapsed since the original injury. These measurements were all made with the goniometer, and the same technique was employed in measuring each elbow. In 8 cases there was a definite diminution in the carrying angle, ranging from 5 to 15 degrees—sufficient to produce a definite cubitus varus. In 1 case there was an increase in the carrying angle of 5 degrees.

In attempting to determine why this alteration of carrying angles should result, we examined carefully the postreduction roentgenograms of those cases which had the greatest amount of cubitus varus, to see if the fragments were locked with slight medial displacement which would be sufficient to obliterate the carrying angle. We could find nothing to substantiate this belief; in fact many of the films showed quite the reverse. We present herewith the roentgenograms of the case which showed the greatest reduction in carrying angle. As will be noted in the postreduction roentgenograms, the fragments are locked in a position of definite radial deviation, or valgus. Furthermore, since we have seen fractures with definite posterior displacement return to normal alinement several years after the original injury, we are convinced that minor lateral displacements will likewise return to normal over a period of years unless some other factor is operating. We believe this factor to be changes in growth of the lower humeral epiphysis as the result of the fracture and that these growth changes persist over a period of years. At the follow-up examinations, measurements of the lengths of the humeri were made from the acromion process to the external epicondyle and from the coracoid process to the internal epicondyle of both extremities. These bony points are easily defined in children and young adults who are not too fleshy, and measurements can be made with a fair degree of accuracy. We consider $\frac{1}{8}$ of an inch to be the limit of measurable error, and measurements that did not exceed $\frac{1}{8}$ of an inch were discounted. When these measurements were tabulated, it was found that the external measurements of the affected elbow exceeded the internal measurement of the elbow by $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in 6 of the 8 cases that showed a cubitus varus. In the case that showed an increase in carrying angle, the external measurement was less than the internal. From this observation we may deduce that the epiphysis of the external epicondyle was stimulated as the result of the fracture and that this stimulus persisted over a period of years. As the result of the increased growth of the epiphysis of the external epicondyle, the carrying angle at the elbow gradually diminished so that the end-result was a varying degree of cubitus varus. The most marked diminution in carrying angle occurred in cases of

Fig. 12. Fig. 13.

Fig. 12. Case 6, F. N. Slight separation of epiphysis of right internal epicondyle. This type of injury was considered to be very trivial in the past, but in our series it invariably results in non-union without impairing function of the elbow.

Fig. 13. Case 6. Seven years after closed reduction showing non-union.

complete fracture with displacement, but in 2 cases of incomplete fracture without displacement, diminution of the carrying angle of 5 degrees or less was noted. This would seem to confirm the observation that it is not the initial displacement which alters the carrying angle, but subsequent growth changes.

Growth stimulation of an epiphysis following fracture is not a new concept and has been reported for both the femur and the radius by Aitken.

FRACTURES OF THE EXTERNAL EPICONDYLE AND CAPITELLUM

There were 28 fractures of the external epicondyle and capitellum in this series, of which 10 returned for follow-up. Three of these fractures were recent and seen the day of injury; the others were old fractures and seen at intervals varying from 2 weeks to many months. The end-results in this group of fractures were not nearly as satisfactory as in the supracondylar fractures. Four of the 10 were poor and the remainder good to normal. The poor results were due to non-union or malunion. Any fracture in which 40 per cent of the cases end in poor results should be considered as a serious lesion. Of particular interest also is the fact that 17 of 28 of these cases came to us many weeks or months after the original injury, all with displaced fragments, apparently most of which were not united. The conventional method of treating this fracture had failed to produce a satisfactory result. It is, therefore, important that we analyze the good results in our future handling of these cases.

Three of these fractures showed no displacement. The end-result in all of these cases was good. One of the remaining 7 had an open reduction at another institution, and bone union resulted after a long period of disability. Another treated by open reduction at this hospital likewise went on to bone union and an excellent end-result. The third treated by closed reduction at this hospital likewise went on to a good end-result. When the poor results were analyzed, it was noted that 3 of the patients treated by closed reduction resulted in non-union. The fourth patient was treated by open reduction in this institution 2 months after the original injury. Postoperative sepsis ensued; the fragment sequestrated and had to be removed. This is the poorest result in the entire series. Thus there were 3 open reductions with a 33⅓ per cent poor result and 4 closed reductions with 75 per cent poor results. It is evident that in fractures of the external epicondyle and capitellum with much displacement, open reduction is probably the method of choice, This does not preclude the possibility of a good result being obtained by closed methods if the fragment can be accurately replaced and maintained until bone union results.

In examining these children many years after the original injury, changes in the carrying angle were observed. In the 3 cases without displacement, 2 showed a diminution in carrying angle similar to supracondylar fractures, indicating, we

Fig. 14.

Fig. 14. Case 7, J. S. Moderate separation of the epiphysis of the right internal epicondyle.

Fig. 15.

Fig. 15. Case 7. Three years after open suture—irregular in outline but apparently well united.

believe, stimulation of the epiphysis of the external epicondyle. This is borne out by measurements which show an increase in length from the acromion to the external epicondyle. In all of the remaining cases an increase in carrying angle was shown, frequently resulting in a marked cubitus valgus due to a diminution in growth of the epiphyses of the external epicondyle. This was especially marked in those cases of non-union. Retardation of growth of the external epiphysis was shown by measurements from the acromion and coracoid to the external and internal epicondyles, respectively.

We believe that the seriousness of this type of elbow fracture is not generally appreciated. In spite of the poor anatomical results, the function of the elbow was excellent in all cases except the one in which the sequestrated fragment was removed. The return of function in this type of injury is exceedingly slow, and it may be a year or more before full extension is obtained. This period is shortened considerably following open reduction if bone union results. Another factor not usually appreciated in the handling of these fractures is the harmful effects of the application of force to increase the range of motion. Forceful passive motions, "pumphandling," the carrying of heavy weights and irons, and other such procedures in common use, lengthen the period of disability and are mentioned only to be condemned. The only physiotherapy indicated during the convalescent care of a fractured elbow is active exercise and active use of the extremity.

SEPARATIONS OF THE INTERNAL EPICONDYLAR EPIPHYSIS

There were 12 separations of the internal epicondylar epiphysis in this series, of which 7 returned for follow-up. The epiphysis for the internal epicondyle appears after the fifth year, so these children range in age from 6 to 11½. All the follow-up examinations revealed non-union of the internal epicondylar epiphysis except one case. This case was the only one in the series in which patient had an open reduction with suture of the separated epiphysis. The other patients were treated conservatively. Even in the patient treated by open suture, the epiphysis is irregular in contour with some overgrowth of bone.

Follow-up examinations from 2½ to 7 years after the initial injury revealed no evidence of the occurrence of growth disturbances such as we have described following both supracondylar and external epicondylar fractures. This is all the more surprising when one considers that here the injury occurs at the epiphyseal plate whereas the other fracture lines are proximal to the epiphyseal plates. Careful measurements from acromion to external epicondyle and coracoid to internal epicondyle reveal normal growth even when the

epiphysis shows evidence of non-union and the carrying angles of both the injured and the normal elbows are the same. It would seem to be evident, then, that the alterations in carrying angles observed in supracondylar and external epicondylar fractures need not be expected to follow separations of the internal epicondylar epiphysis, even if non-union should occur.

We believe that if non-union of the separated internal epicondylar epiphysis is to be avoided in the presence of even minor degrees of separation, an open operation with suture of the displaced fragment is necessary. However, this follow-up study also shows conclusively that non-union of a separated internal epicondylar epiphysis in no way prejudices either the structure or the function of the elbow joint; and except for an undue prominence of the internal epicondyle, there are no other external evidences of non-union.

SUMMARY

1. This study confirms the prevailing opinion that the functional end-results in the treatment of supracondylar fractures are uniformly good, even when the fractures are not necessarily accurately reduced.

2. A diminution in the carrying angle of the elbow producing a cubitus varus deformity is often a sequence following supracondylar fractures (28 per cent in this series), and may be caused by stimulation of the external epicondylar and capitellar epiphyses due to the fractures. This anatomical derangement usually does not affect the function of the elbow.

3. Fractures of the external epicondyle and capitellum in childhood are serious injuries, and if treated in the conventional manner, will result in a large percentage of cases in non-union and severe distortion of the elbow. In the presence of even minor displacement which cannot be completely corrected, open reduction is the method of treatment that offers the best end-result.

4. Separation of the epiphysis of the medial epicondyle has been considered a minor injury, but if non-union is to be avoided open suture is advised.

MULTIPLE PRIMARY CARCINOMA

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LATELY considerable interest has been shown in multiple primary malignant tumors. Billroth is credited with being the first to report their occurrence, in 1869. Since then, many cases have been reported in the literature but not in any great numbers until recently. It was not because they did not formerly occur, but they were very likely overlooked. Undoubtedly, many primary lesions have been mistaken for metastases.

Goetze suggests the following criteria as essential in making a diagnosis of multiple primary carcinoma: (1) The tumor must have the macroscopic and microscopic appearance of usual tumors of the organs involved; (2) exclusion of metastasis must be certain.

The diagnosis may be confirmed by the character of the metastases. It is rather exceptional in multiple primary cancers, however, for more than one to metastasize. This undoubtedly is accounted for by the difference in the activity of the growths; for instance, grade 4 carcinoma would naturally metastasize more quickly than grade 1. Then again, when two cancers are found, one may have developed long before the other and, naturally, the one that developed first would be more likely to metastasize, especially if the two cancers were of the same grade.

Without offering substantial proof Broders suggests that the average grade of multiple primary malignant tumors should be higher than that of a like group of single malignant tumors.

In an article recently published by Kirshbaum and Shively,[1] a report was made of 1,411 autopsies performed at the Cook County Hospital in cancer cases. There were 25 cases of multiple carcinoma found in this group, an incidence of 1.77 per cent. Of these, only 4 patients showed metastases from both tumors. An individual with a malignant tumor usually succumbs to it before a second primary growth develops or before it is recognized.

Multiple primary malignancies are found more often during surgical operations than at postmortem examinations: Hurt and Broders of the Mayo Clinic report 3.34 per cent found at operation. Based on the average of other observers, the incidence is about 4 per cent.

In the series of 25 cases at Cook County Hospital, the colon was more frequently involved in multiple carcinoma than was any other organ; the colon was involved in 13 of the cases of carcinoma reported.

It is generally recognized that many people have a congenital, or acquired, predisposition to cancer, others are probably endowed with resistance. In spite of the tremendous amount of research on cancer, it is still very much of an enigma. While the genetic background of cancer is still obscure, we hope that individual and collective reports may help clarify the problem.

It has been quite well established that an inherent or acquired susceptibility to cancer exists in certain individuals. Chronic irritation is recognized as one of the main causes of cancer. We know that chronic irritation may occur in a number of organs in which cancer is likely to occur, for instance: gastric ulcer, polyps of the colon and rectum, lacerated cervices, and chronic mastitis. All of these pathological conditions may be considered as forerunners of cancer in a susceptible individual and two or more organs may be involved at the same time. For example, it is not uncommon to have a peptic ulcer and polyps of the colon in the same individual. It does not seem strange, therefore, that we should have multiple primary carcinoma. In fact, it seems rather strange that we do not find them more often. It is quite likely that they are occasionally overlooked.

When a patient is operated upon for cancer, careful exploration should be made for multiple carcinoma, as the fact that a malignant growth is present indicates that the patient is susceptible to cancer. If the second primary malignant lesion happens to be in a very early stage, it may not be possible to recognize it. Not infrequently, a second primary growth may be mistaken for a metastatic growth. In my personal experience, I do not recall more than 6 definite cases of multiple primary cancer.

Recently I have had 2 of these cases that seem to be of sufficient interest to present more or less in detail, as they both illustrate certain features which make them seem worth while reporting. In both cases there were two primary malignant tumors, both of which may be considered as having developed simultaneously.

Presented at the annual meeting of the Western Surgical Association, Los Angeles, California. December 15–16, 1939.

[1] J. Lab. & Clin. Med.

CASE 1. The first patient, a woman 48 years of age, came to see me in August, 1938, complaining of some rather indefinite abdominal symptoms—general abdominal distress, moderate intermittent distention, and occasional passing of blood from the rectum. As she had hemorrhoids, I assumed that the bleeding came from them.

Because of the symptoms complained of she was sent to a roentgenologist for study of the colon. X-ray examination revealed the presence of a polyp in the descending colon about 7 inches distal to the splenic flexure. A considerable amount of barium was retained by the polyp, a fact indicating the likelihood of a cauliflower type of growth, which was probably malignant.[1]

Operation was performed on September 12, 1938. A midline incision was made at the site of the scar following a hysterectomy performed 7 years previously. The transverse colon was fixed to the cecum by adhesions and the ileum was fixed to the peritoneum at the site of the old incision. These adhesions were freed and the bowel was carefully peritonealized. Exploration of the descending colon revealed the polyp about 7 inches distal to the splenic flexure (Fig. 1). Segmental resection of the bowel seemed the safest procedure in order to prevent future formation of polyps. About 7 inches of bowel was removed in this case, by a Mikulicz type of operation. The fistulous tract following the Mikulicz operation was closed on November 21, 1938. Pathological examination of the polyp showed it to be an adenocarcinoma grade 1 (Fig. 2).

Fig. 1. Polyp of descending colon.

Seven weeks later the patient came to see me on account of a tumor in the left breast. The tumor had the appearance of cancer, but as she had a cold at the time, I had to postpone the operation until February 1, 1939, when the tumor was removed. A frozen section revealed the tumor to be a duct carcinoma (Fig. 3). A radical operation was performed. She made a satisfactory recovery from this operation, but returned in 5 months with a tumor in the right breast, which had the gross appearance suggestive of cancer. A complete mastectomy was done; as no malignancy was found, a radical operation was not performed. In June, 1938, a benign cystic tumor had been removed from this breast.

[1]It is suggested by Broders, that there is probably a malformation of the bowel which accounts for the formation of these polyps.

Lockart-Mummery has studied intensively 50 cases of solitary polyp of the rectum over a period of 1 to 15 years, examining these patients every 4 to 6 months during that time. He found that 50 per cent had recurrence in or near the same area where the original polyp was found. In some instances it was on the opposite wall of the bowel whence it first occurred. Thirty per cent of the patients had more than one recurrence, some as many as 9. In some cases, recurrence was so frequent that he found it necessary to remove the entire rectum. In twenty-five per cent of his cases malignancy developed at the tip of the polyp, but in no case in which the polyp was removed at the base did cancer extend to the bowel wall, showing quite definitely that the early adequate removal of the polyp prevents the development of cancer of the colon or rectum from the polyp.

Fig. 2. Photomicrograph of adenocarcinoma of a polyp from the descending colon. Section taken from distal end of polyp, grade 1.

CASE 2. The second patient, a woman 48 years of age, was seen on January 24, 1939. She stated that about 3

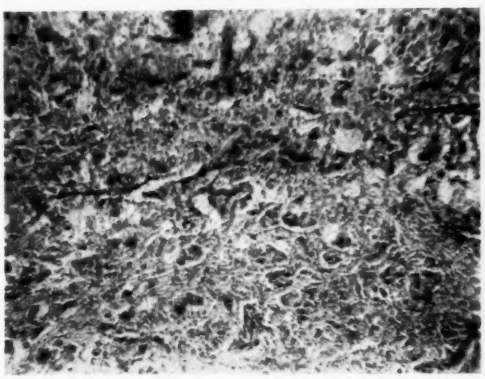

Fig. 3. Photomicrograph of duct carcinoma of breast.

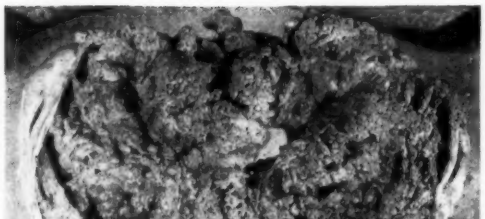

Fig. 4. Photograph of papillary adenocarcinoma of ovary. Uterus and other ovary shown in photograph.

weeks before, she was seized with a severe pain in lower right abdomen, which came on rather suddenly; the severe pain gradually subsided. She had been troubled with moderate pain in lower abdomen for several months. Sometimes the pain would radiate to the left side. Examination revealed the presence of a large pelvic tumor about the size of a full term pregnancy. Urinalysis was negative. Hemoglobin was 84 per cent; red blood cells, 4,000,000; white blood cells, 7,200. Blood pressure was 140/90 and pulse ranged between 96 and 100.

It was suspected that on account of the apparent rather rapid growth of the tumor, it was probably malignant. She stated that she had been treated for heart trouble 2 years previously by a cardiologist and was worried about her heart. She was advised to go to the hospital at once, as there was no indication at this time of any serious heart trouble and there was definite indication for urgent surgery. She did not take the advice given, however, and was not seen again for 10 days, at which time she stated she was ready to go to the hospital for operation.

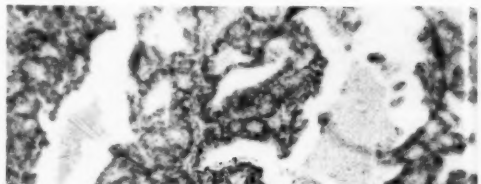

Fig. 5. Photomicrograph of papillary adenocarcinoma of ovary.

Operation was done on February 6, 1939. A midline incision was made, extending from the umbilicus to the pubes. A tumor was found fixed to the abdominal wall and in an attempt to free it, it ruptured before the fluid could be aspirated, and about 4 or 5 quarts escaped. After that, it was quite easy to free the tumor and trace it to its origin, in the left ovary. It had a comparatively small pedicle and was quite easily removed (Fig. 4).

The pathological report from a frozen section showed a papillary adenocarcinoma of the left ovary (Fig. 5). As this type of cancer tends to metastasize to the other ovary, a subtotal hysterectomy was done, and the other ovary removed.

The patient was not in very good condition, and every effort was being made to conclude the operation as quickly

Fig. 6. Adenocarcinoma of cecum located at base of appendix, causing obstructive appendicitis.

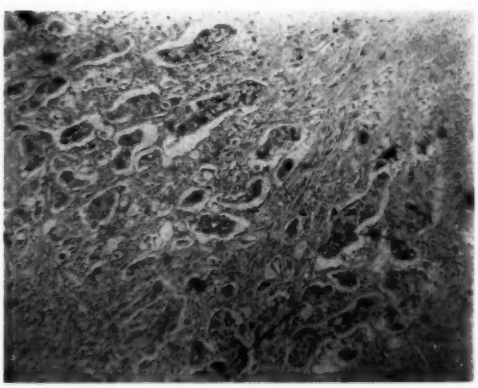

Fig. 7. Photomicrograph of adenocarcinoma of cecum grade 3.

as possible. However, on completion of the pelvic operation, an exploration was made and the appendix was found greatly enlarged and inflamed. Examination of the cecum at the base of the appendix revealed a hard mass, which had the gross appearance of carcinoma (Fig. 6). Appendicitis, which was present in this case, was undoubtedly caused by the obstruction at the base of the appendix, produced by the gradual extension of the cancer.

Not caring to subject the patient to any more surgery at this time than was absolutely necessary, it was decided that the Mikulicz type of operation was the safest procedure. Accordingly, the mesentery of the ascending colon was severed and vessels ligated. The ileum was sutured to the ascending colon well away from the growth, and the mass including the appendix was exteriorized. Four days later, the appendix ruptured. The ileostomy tube functioned well and it was not necessary to remove the growth until 1 week after the primary operation. Pathological report showed the growth to be adenocarcinoma grade 3 (Fig. 7). On the ninth day a crushing forceps was placed on the diaphragm, separating the ileum and ascending colon. It took the forceps 6 days to cut through the diaphragm.

The external fistula was closed 2 months after the primary operation. Patient has been quite well since, but a recent examination revealed recurrence of cancer; probably it is a recurrence of the papillary adenocarcinoma of the ovary, as that was the more advanced of the two growths.

SUMMARY

In Case 1, it was quite evident from the fact that entirely different structures were involved, and the tumors were so far removed from each other, that they were independent primary growths. It is interesting in this case that the patient was operated upon 4 different times within a period of 13 months for various tumors; 2 of these proved to be cancers and 2, benign growths; therefore, 50 per cent of the tumors for which she was operated upon during this period, proved to be malignant.

In Case 2, it seems quite likely that the papillary adenocarcinoma of the ovary had probably been present for some time, as it was a low grade type of cancer and very large. The adenocarcinoma of the cecum, on the other hand, had probably started to develop rather recently, as it was still comparatively small. This growth was found to be of a much higher grade of malignancy.

The reason the carcinoma of the cecum was not considered a metastatic growth from the ovary was that there was no evidence of involvement of the serous coat of the bowel, and again the tumor of the bowel had a much firmer feel than the growth in the ovary. The macroscopical appearance of the two malignant tumors was entirely different.

ESSENTIAL PROBLEMS IN THE SURGICAL TREATMENT OF INGUINAL HERNIA

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THERE is a widespread tendency among surgeons to approach the problem of the surgical treatment of inguinal hernia from the standpoint of the routine application of one or another of the standard operations rather than from an analysis of the actual anatomical defect to be repaired. Operation for hernia is frequently among the first to be entrusted to the initiate in surgery, and the conceptions of treatment thus early acquired are usually accepted without question and are often permanently retained. Discussions on the subject, therefore, frequently resolve themselves into testimonial meetings, affirming the value of this or the other method or technical detail or suture material, without regard for the essential underlying pathological features of the disease to be treated. The purpose of this paper is not to advocate any one specific treatment for inguinal hernia, but to redirect attention to the actual surgical problems it presents.

In order to clear the ground for a rational consideration of the hernia problem, several sources of confusion must be eliminated. First, there is a widespread complacency as to the results obtained by the surgical treatment of inguinal hernia. This satisfaction is usually based upon impression, or upon the assumption that failure of patients to return is indicative of a successful end-result of the operation. When the acid test of actual follow-up examination is applied, however, the results are found to be much less satisfactory and, in the case of direct hernias, profoundly disconcerting. Statistics as to the late results of surgery in indirect hernia (15) report recurrence rates ranging from 2 to 20 per cent. The results in direct hernias are definitely poorer. In their highly significant paper entitled "Direct Hernia: A Record of Surgical Failures," Andrews and Bissell (3) reported their own recurrence rate to be 27 per cent, and tabulated results from other clinics which ranged from 9.5 to 32 per cent. The average rate for the entire table was 20 per cent. Gallie (7) states that records from hospitals in which this subject has been studied show that recurrence takes place in from 40 to 50 per cent of the cases. With these figures in mind, let us demand that all statements attesting the value of any therapeutic measure for the control of inguinal hernia shall be based upon nothing less than the actual follow-up examination of patients after the lapse of an adequate postoperative time.

A second fact to be emphasized in bringing the discussion of the treatment of hernia to a logical basis is that there are no consistent differences obtained with the various standard operations for hernia. Individual surgeons may report better results with one method as against all others, but, when the literature as a whole is surveyed, the same may be found true of the other procedures in turn. No one method regularly yields significantly better results than do the others. Nevertheless, one hears the merits of the routine techniques debated with great heat, as if acceptance of one or another is the secret to successful herniorrhaphy.

Much of the confusion attending discussions on the treatment of inguinal hernia is due to the failure to differentiate adequately between direct and indirect types. Sufficient clinical and investigative data have been accumulated to indicate that these are two distinct diseases, based upon different congenital anatomical predisposing characteristics, producing different defects, requiring correspondingly different surgical attacks, and with similarly different prognoses. An attempt will be made here to define the actual lesion present in the different types of inguinal hernia and to indicate the essential problems in its logical repair.

A final source of confusion in speaking of inguinal hernia is the ambiguity and inaccuracy of anatomical description and nomenclature applied to the structures occupying the inguinal region. The anatomy of this area, with special reference to the problems of inguinal hernia, has recently been studied by Anson and McVay (4, 5, 9) in the anatomical laboratories of Northwestern University Medical School. The following résumé is based upon their descriptions.

ANATOMY OF THE INGUINAL REGION

The structures comprising the spermatic cord, the vas deferens, and the spermatic vessels (and

From the Division of Surgery, Northwestern University Medical School and the Michael Reese and Chicago Memorial Hospitals.

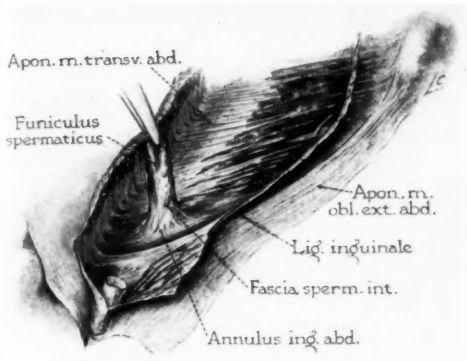

Fig. 1. Abdominal inguinal ring as seen from in front.

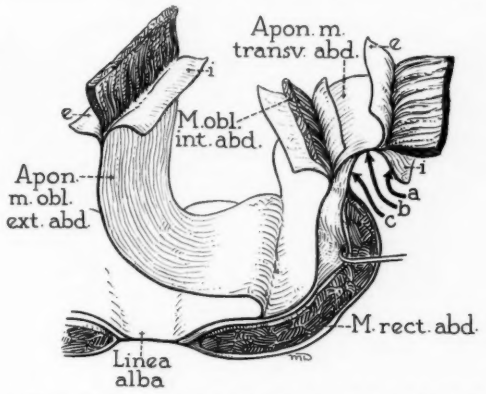

Fig. 2. Section demonstrating muscles of the abdominal wall and their investing fascias, below the level of the linea semi-circularis. (From Anson and McVay, loc. cit., 4.)

in the female, the round ligament) course in the retroperitoneal tissues to converge at the abdominal inguinal ring. This is a hiatus in the posterior fascial wall of the inguinal canal, usually referred to in the surgical literature as the "transversalis fascia," and through it the cord structures leave their retroperitoneal position to traverse the abdominal wall on their way to the scrotum. The orifice is not a circular opening as the term "ring" would imply, but rather, a funnel-shaped aperture, the fascial fibers continuing down over the cord as the internal spermatic fascia (Fig. 1).

The posterior fascial wall of the inguinal canal, as stated, is usually referred to as the transversalis fascia. This structure is importantly regarded in current discussions of inguinal hernia, and there is some disagreement as to its origins and continuations. Anson and McVay emphasize the fact that each of the flat muscles of the abdomen, as well as those elsewhere, has an anterior and a posterior investing fascia. These investing fascias are continued over the aponeurotic fibers of the muscles, so that aponeuroses consist of three fibrous layers, the true tendinous fibers of insertion and the two investing membranes. The term "transversalis fascia" is usually used to denote the posterior investing fascia of the transversus abdominis muscle. When the muscle ends in an aponeurosis, however, the term is applied to that portion of the triple aponeurotic layer that extends caudally beyond the lowermost fleshy fibers to its insertion in the pubic bone. Mesially, this layer passes *anterior* to the rectus muscle, together with the other portions of the transversus abdominis aponeurosis below the semicircular line of Douglas, to contribute to the anterior rectus sheath. The posterior investing layer, however, splits at the edge of the rectus muscle, and its very thin posterior half passes behind the rectus as its posterior investing fascia (Fig. 2).

The transversus abdominis aponeurosis (transversalis fascia) alone constitutes the posterior wall of the inguinal canal, and upon it the spermatic cord lies (Fig. 3). The only other structure lying behind the cord, and contributing to the strength of the posterior wall is a lateral expansion of the insertion of the rectus muscle outward onto the pectineal line of the pubis. This has often been called the aponeurotic inguinal falx. The term is confusing, however, because, unfortunately, it has also been applied to the so called "conjoined tendon." The expanded rectus tendon, when present, lies immediately superjacent to the transversus layer. Data as to the percentage of subjects in which it was found, and the variations in its width, will be presented in a forthcoming publication by the authors mentioned.

As the spermatic cord comes through the internal ring, it is covered by the arching fibers of the internal oblique muscle. This muscle constitutes an effective sphincter, guarding the introitus of the inguinal canal. The lower fibers of this muscle take their origin from the pectineal fascia (9), just posterior to the inguinal ligament, and insert fan-wise into the linea alba down to and including the pubic tubercle. Those arising inferior to the abdominal inguinal ring invest the cord structures in loose loops and comprise the cremasteric layer of the cord. In most subjects (Fig. 4), including those with indirect inguinal hernias, the entire inguinal region between the

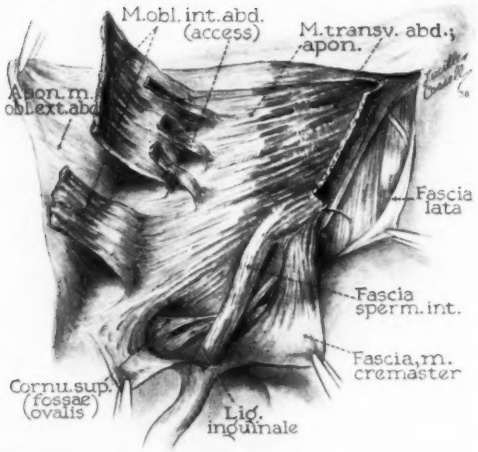

Fig. 3. Transversus abdominis aponeurosis forming posterior wall of the inguinal canal. (From McVay and Anson, loc. cit., 9.)

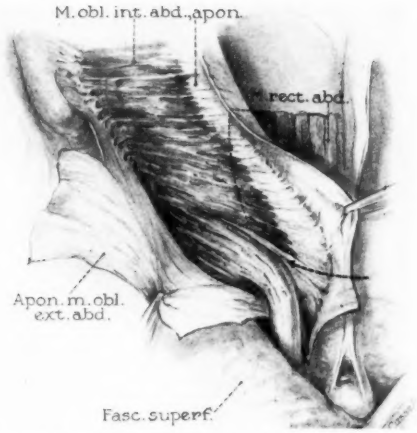

Fig. 4. Internal oblique muscle, showing narrow cleft between abdominal and cremasteric portions. (From Anson and McVay, loc. cit., 4.)

inguinal ligament and the rectus sheath is covered and protected by this muscular layer, with only a slight interstice, largely artifactual, between the abdominal and cremasteric portions of the muscle. When this type of internal oblique muscle is present, direct hernia does not occur. The arrangement predisposing to the development of direct hernia will be described later.

The importance of the internal oblique muscle in safeguarding the inner opening of the inguinal canal cannot be overemphasized. Its action has been likened to that of a sphincter or shutter. When the abdominal muscles contract to increase the pressure within the abdomen, the fibers shorten and approximate themselves to the inguinal ligament, compressing the cord. The efficacy of this sphincter can be demonstrated when local anesthesia is used in operations for indirect inguinal hernia. If a finger is inserted into the sac, extending into the abdominal cavity, and the patient strains or coughs, the muscle can be felt contracting down upon the finger like a true sphincter. That it really functions in this capacity is demonstrated by two frequently observed clinical facts. The sac of indirect hernias is very often found to have a band of fibrosis or of traumatic peritonitis encircling it at its neck, as has been described by Schrager and Gault, the result of sphincteric muscle pressure upon it. More striking still is the fact that many patients with inguinal hernias reach adult life without becoming aware of the existence of the hernia. A certain number of these have sacs of the "congenital" type, in which the peritoneal sac is continuous with the tunica vaginalis testis, indicating beyond doubt that the hernia has been present since birth. The ordinary types of indirect hernia are also generally considered to be of congenital origin. Nevertheless, thanks to the efficiency of the internal oblique sphincter, no bowel or omentum finds its way into the sac until adult life or even middle age is reached. Another expression of this sphincteric resistance is the difficulty sometimes encountered in recently discovered hernias, in bringing contents down into the sac during examination. Equal difficulty may be met in reducing the hernia when once it has been brought down and strangulation, when it does occur, usually takes place at the internal ring.

The anterior wall of the inguinal canal is formed by the aponeurosis of the external oblique. This hard, fibrous layer supports the muscular walls of the canal as a tire casing does the inner tube. A hiatus in the fibers of the aponeurosis provides the subcutaneous or external inguinal ring, through which the cord gains access to the scrotum. The inguinal ligament is a fold of the external oblique aponeurosis stretching from the anterior superior iliac spine to the pubic tubercle. It is usually described as a fixed structure, continuous with the fascia lata of the thigh, and because of this serves as the sheet anchor in most hernial repairs, the other layers being brought

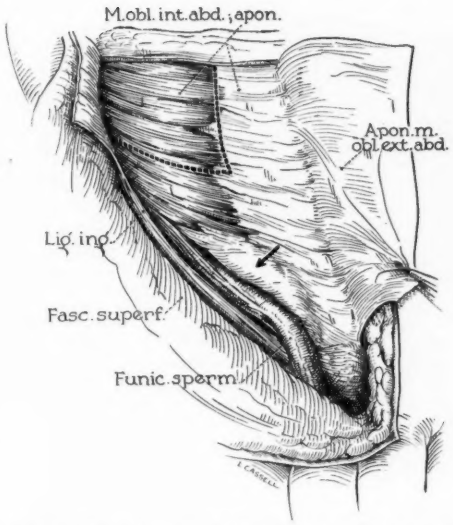

Fig. 5. Type of internal oblique muscle predisposing to the development of direct hernia. Note absence of muscle fibers in lower portion. (From Anson and McVay, loc. cit., 5.)

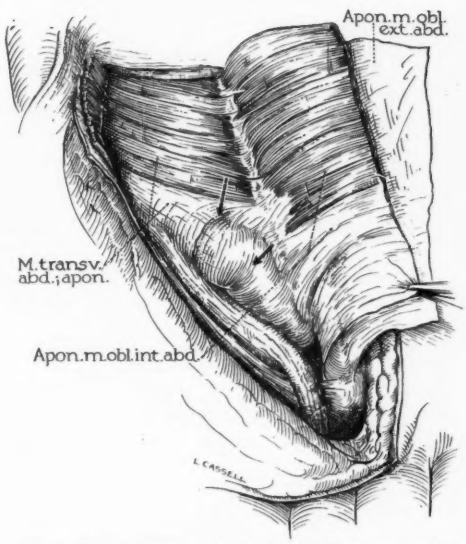

Fig. 6. Transversus abdominis layer from same subject as Fig. 5. Note direct hernia forming. (From Anson and McVay, loc. cit., 5.)

down and sutured to it. McVay (8) has recently pointed out that the aponeurotic fibers end in a free edge, and the only attachment between the inguinal ligament and the thigh fascia is by means of the very thin investing fascia. This he considers a fundamental fallacy in the Bassini and allied herniorrhaphies.

The inguinal canal bounded by the structures described is the passage pursued by the spermatic cord through the abdominal wall. It is a long, oblique, valve-guarded channel, similar in design to the intramural portions of the ureters or of the common bile duct. Wherever, indeed, in the body a duct enters or leaves a hollow viscus, the pattern is the same, and for the same reason. Just as increased intravesical tension from the contraction of the bladder musculature during the act of micturition compresses the intramural portions of the ureters, and forces urine out through the urethra rather than back up into the ureters, so contraction of the abdominal muscles increases the pressure within the inguinal canal, constricting and narrowing it to prevent the escape of abdominal contents.

ETIOLOGY OF INGUINAL HERNIA

There is general agreement today, as has been stated, that indirect and direct hernias are totally different diseases, each dependent upon a different developmental defect, each having its own anatomical and pathological characteristics, and presenting, consequently, its own prognostic and therapeutic problems. Indirect hernia is due primarily and solely to the persistence *in toto* or in part of the processus vaginalis testis. No other developmental defect regularly accompanies this common type of inguinal hernia. In all other respects the abdominal parietes conform to the normal described. Only the persistence of an embryonic structure can lead to the development of a hernia through the internal ring. There is no evidence that any amount of force or trauma can otherwise produce such a protrusion.

The evidence for this rather dogmatic statement lies in the unvarying position and attachment of the sac with reference to the cord structures. Whether the hernia is of the "congenital" or the ordinary type, these relations are identical. The sac always lies in the middle of the cord, immediately anterior to, and in direct apposition with, the vas deferens, and is covered by the cremasteric and internal spermatic fascial layers. An areolar type of tissue connection binds the sac to the other components of the cord. Unless modified by pressure or inflammation, these anatomical findings are the same. They are too constant to be the result of an accidental rupture through the abdominal wall and can be explained

only on the basis of the persistence of a normal embryological structure.

Given a preformed peritoneal process communicating with the abdominal cavity and extending into or through the inguinal canal, manifest hernia need not necessarily occur. The sac may remain empty for many years, and even throughout life. This is possible, as has been detailed, by virtue of the function of the internal oblique sphincter. In most individuals with a congenital sac, however, omentum or bowel finds its way down past the sentinel at the internal ring at some time during childhood or in adult life, and the hernia becomes manifest. When herniation does occur, the ring becomes stretched and dilated, either suddenly and abruptly following strain or injury, and accompanied by pain and tenderness, or gradually, silently, and imperceptibly. In either event, subsequent pistoning back and forth of omentum or intestine results in increasing enlargement of the inner ring. This enlargement cannot progress upward, because of the protection afforded by the transversus abdominis and internal oblique muscles. Necessarily, therefore, it enlarges downward and, in so doing, comes to extend beyond the overhanging and protecting internal oblique sphincter. Thus, a stage is soon reached wherein sphincter control is entirely lost, and contents glide in and out of the canal with changes in abdominal pressure or of bodily position.

In very old, very large hernias, particularly in those in which a truss has been worn for a long period, further changes involving the musculofascial wall may be produced. In such cases, the internal ring may extend from its original position above and lateral to the inferior epigastric vessels down to the pubis. In addition, the overlying muscles which had developed normally, may undergo attrition and atrophy from excessive stretching as well as from truss pressure. When this has occurred, the situation approaches that found in direct hernia, and a similar solution is required.

Direct inguinal hernia begins as a disease totally apart from the indirect variety. It, too, is based upon a congenital developmental anomaly, but one that is entirely different from the one responsible for indirect hernia. As was pointed out in a recent contribution (14), direct inguinal hernia is due to failure or absence of the lowermost fibers of the internal oblique muscle. In the normal subject herein described, the entire inguinal region is covered and protected by the internal oblique muscle, a narrow cleft separating its abdominal from its cremasteric portions. The interval between the lateral border of the muscle and the inguinal ligament is just large enough to accommodate the cord with its cremasteric covering. Thus, no portion of the canal floor is left without muscular protection.

In a certain number of persons, however, the lower, oblique fibers of the muscle are absent, its fleshy body ending with more or less horizontal fibers arising at the level of the internal ring and inserting into the rectus sheath (Fig. 5). This leaves a triangular area of variable size in which there is no muscular covering for the transversus aponeurosis constituting the posterior wall of the canal. This area, called the inguinal triangle, is bounded above by the lower free margin of the internal oblique, by the rectus sheath medially, and the inguinal ligament laterally. The range in size of this space as seen in anatomical dissections and also during operations for direct hernia was tabulated in the previous publication.

In persons with this type of abdominal musculature, the entire intra-abdominal pressure is exerted upon the aponeurotic floor of the canal. The capacity of this membrane to withstand pressure will depend largely upon its inherent strength and firmness. If, as a result of the innumerable slight strains incident to daily life and work or, conceivably, because of some sudden and excessive strain or trauma, the transversus structures prove inadequate, direct hernia will result. Such herniations are, characteristically, broad bulgings through stretched and weakened aponeurotic fibers.

TREATMENT OF INGUINAL HERNIA

With this anatomical and pathological background, it is possible to define the problems encountered in the treatment of inguinal hernia. Indirect hernia, as stated, is a protrusion into a preformed sac with, usually, secondary dilatation of the internal ring. Logical treatment, therefore, should consist in removing the sac and narrowing the ring to its normal dimensions. When these two steps are accomplished, the inguinal canal has been restored to a normal state, and further building up of its posterior wall by plicating and re-plicating the various and sundry layers of muscle and fascia have no bearing whatever on preventing eventual recurrence of the hernia. Direct hernia, on the other hand, is a protrusion through a torn and stretched posterior fascial wall, due to the absence of overlying muscular support. Here the problem, in its essentials, is the repair of a hole in the fascial floor of the canal and its subsequent reinforcement to prevent further herniation. Since there is no way of making

muscle grow where it is wanting, a fascial plastic operation must be done. Thus, the two types of inguinal hernia present totally different problems which would appear logically to demand totally different operative attacks. Nevertheless, most surgeons today utilize the same operative procedures for both types of hernias.

Repair of indirect hernia. The problem in indirect hernia has been defined. It consists of a pre-formed sac with, usually, some dilatation of the internal ring. Everyone is agreed that treatment should begin with removal of the sac. The emphasis, however, which is frequently placed upon extirpation of the sac by its roots, often with a portion of the normal peritoneum is, in my opinion, exaggerated. The peritoneum is an elastic and yielding membrane, and a dimple in its surface would not be an important factor in the production of a hernia if there were no fascial defect through which the dimple could protrude. In infants and children, and in older individuals with very recent hernias that have as yet caused no dilatation of the ring, simple removal of the sac is all that is necessary to restore the affected inguinal canal to normal. Herzfeld, in an "experience of many thousands of cases," finds that simple removal of the sac is all that is required for the cure of hernias in infants. Numerous other writers have expressed a similar view, and I have found this limited procedure adequate whenever the ring is of normal diameter.

The usual indirect hernia encountered at the operating table exhibits, however, an enlarged internal ring superimposed upon the pre-formed sac. Rational treatment, it would seem, would demand narrowing of the ring after the sac has been removed. This is readily accomplished by placing a stitch or two, or possibly three, in the transversus layer. In order to visualize the ring, the cord is held upward and the internal oblique is retracted medially. The dilated internal ring thus exposed is usually triangular in shape with its apex directed downward. The inferior epigastric vessels may be seen crossing its lower angle. The hiatus which is normally completely occupied by the cord will frequently permit considerable bulging of properitoneal tissue, and will often admit two or three fingers alongside the cord. Closure should be from below upward, so that the opening left may be as high as possible, and the canal as long and as oblique as in the normal. Because the lateral crus of the ring is very narrow, I usually unite the medial edge of the transversus aponeurosis to the inguinal ligament with several fine silk sutures (Fig. 7). No tension is required to bring these two fibrous structures in apposition. When the ring is closed, the canal has been restored to normal, and further operative manipulation is superfluous. The cord is merely dropped back in its original position, and the aponeurosis of the external oblique reunited over it.

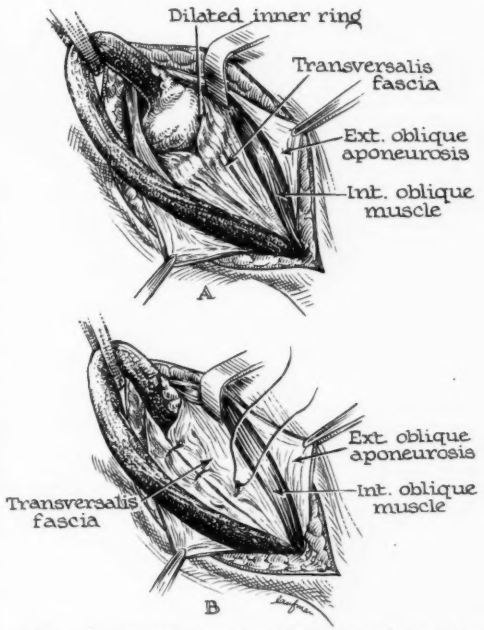

Fig. 7. Repair of indirect inguinal hernia, after sac has been removed. A, Dilated internal ring, with pro-peritoneal fat bulging through it. B, Closure of ring by suture of its medial margin to inguinal ligament. Internal oblique muscle is retracted medially, and is not included in this suture layer.

It will be noted that suture of the internal oblique muscle (the so called conjoined tendon) to the inguinal ligament is not a part of the operation. This step, which constitutes the essential feature of the Bassini operation and all of its modifications, is avoided in operations for both indirect and direct inguinal hernia because it is irrelevant and ineffective, and it may be positively injurious. For these reasons, which will be enlarged upon, there is a growing belief that the Bassini operation should be relegated to a place with the other historic contributions to surgery that have, in time, become obsolete.

Suture of the internal oblique to the inguinal ligament is irrelevant, as stated, because it purposes to build up the floor of the inguinal canal. By definition, and by the pathological description herein detailed, indirect hernia is a protrusion

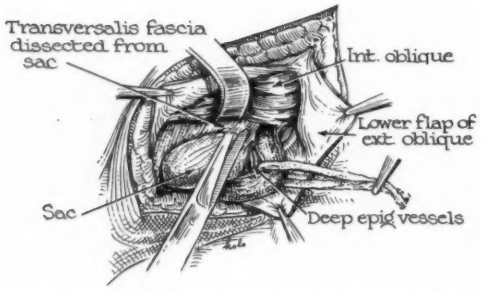

Fig. 8. Direct hernia. Method of freeing sac by incising fibers of transversalis fascia.

through the internal ring and, in most cases, there is nothing wrong with the posterior wall of the canal. Suture of the internal oblique across the posterior wall not only does not contribute to the repair of the actual lesion present, but gives the surgeon a false sense of security in the feeling that he has built up a firm inguinal floor, and tends to lead him to omit the one really pertinent step required, namely, the exposure and suture of the dilated internal ring.

The Bassini step, in addition to being irrelevant to the purposes of the operation, is also ineffective. It has frequently been shown (6, 11) that muscle and fascia do not unite firmly, and failure of union of the internal oblique with the inguinal ligament is regularly found at operations for recurrent hernia. The term "conjoined tendon" is avoided deliberately in this discussion because it is at best a euphemistic misnomer. The surgeon is often seen taking a stitch into fleshy red muscle, saying as he does so that he is suturing conjoined *tendon* to the inguinal ligament, and this term is almost invariably used in descriptions of operations for hernia. It must be obvious that contracting, living muscle cannot be sutured, with any expectancy of permanent union, to a rigid and unyielding structure with stitches that draw the muscle fibers out of their normal line. When contractions of the abdominal muscles are resumed, there is a pull on the suture line, and if the sutures do not yield, they must cut through, leaving, perhaps, a narrow scar to mark their former location. The proof, as stated, of the inadequacy of muscle-to-fascia union is the finding at operation for recurrent hernia that these structures have pulled away and have returned to their original positions.

Definite injury to useful structures may result from this procedure. The significance of the internal oblique muscle as the sphincteric safeguard at the introitus to the inguinal canal has been described. Suture of this muscle with its attendant deformity, fixation, and cicatrization must certainly impair its capacity to function. This damage outweighs any possible benefit derived from a Bassini suture.

Perhaps the greatest injury to the canal is done in those operations that attempt to provide maximal strength for the posterior wall by bringing all of the layers behind the cord, displacing this latter structure to the subcutaneous position. Nature's mechanism of providing a valvular outlet for the cord is thereby defeated. The patient is left, instead, with a short straight canal which is in direct line with the intra-abdominal force. The wall cannot be sutured snugly enough about the cord, in these operations, to prevent recurrence of the hernia without strangulating the cord. Perhaps, because of the intermittent expansions and contractions with the pulsations of the spermatic vessels, the cord works itself loose, and a hiatus occurs about it. The findings at reoperation in such instances are almost invariably the same. There is a direct protrusion of peritoneum just above the cord leading immediately into the subcutaneous tissue. The problem of repair of such recurrence may be difficult since further tightening of the wall about the cord offers no greater security than did the original one, and the musculofascial wall has often been sufficiently damaged to make the return of structures to their normal relations no longer possible.

In old, large, long-standing indirect hernias, particularly if a truss has been worn for a long time, there may be destruction of the entire posterior canal wall from pressure of the hernial contents. In addition, there may be atrophy, relaxation, and attenuation of the overlying musculature, with even fragmentation of the external oblique aponeurosis. In such cases, the findings are analogous to those in direct hernias, and similar problems are presented. The therapeutic solution to these problems will be discussed below.

Repair of direct hernia. The essential therapeutic problem in direct hernia consists of a defect in the fascial floor of the canal due to insufficient support from absence of the overlying muscles. The inadequacies of the conventional operations are more glaringly obvious than in the indirect variety. Andrews has pointed out that the usual procedures attempt to close a triangular defect by sewing together two sides of the triangle. The larger the defect, the more tension will be required to bring the internal oblique muscle to Poupart's ligament. That the usual methods are

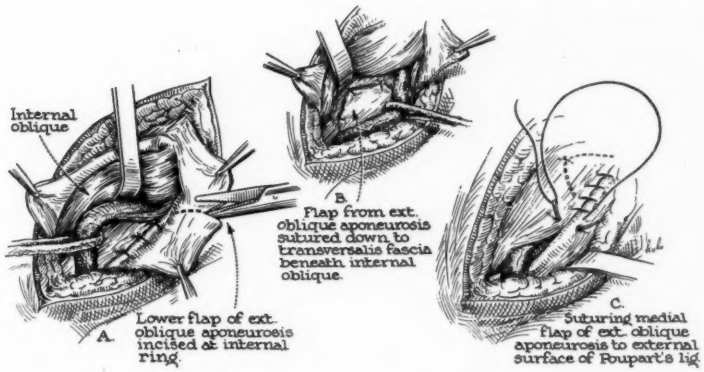
Internal oblique
A.
Lower flap of ext. oblique aponeurosis incised at internal ring.
B.
Flap from ext. oblique aponeurosis sutured down to transversalis fascia beneath internal oblique.
C.
Suturing medial flap of ext. oblique aponeurosis to external surface of Poupart's lig.

Fig. 9. Repair of direct hernia. Transversus aponeurosis sutured to inguinal ligament and reinforced with flap from lateral leaf of aponeurosis of external oblique.

inadequate is revealed by the statistics herein cited, showing recurrences in from one-third to one-half of the patients operated upon. Because of these poor results, and because the patients are often made worse by an unsuccessful operation, Andrews has advised against operation in the usual cases of direct inguinal hernia.

Logical solution for the problem of direct hernia should consist of repair of the hole in the transversus layer (transversalis fascia), and reinforcement of the repaired fascia by some type of fascial plastic operation. Treatment begins by freeing the sac from the stretched and torn fascial fibers coursing over it, and inverting it into the retroperitoneal position. There is no point in opening the sac in the usual direct hernia because the sac is not long and finger-like as it is in the indirect variety, but is a short, blunt, dome-shaped bulging through the fascial floor. These sacs are frequently fatty and opaque. This, plus their median position, increases the danger of injury to the bladder. It is safer, quicker, and just as satisfactory merely to return the unopened sac to the retroperitoneal space and to close the fascia over it.

An exception to this rule is the relatively infrequent diverticular type of direct hernia. Here, the sac emerges through a small, sharply defined aperture which is usually situated near the lateral edge of the rectus muscle. Such sacs are long and finger-like, and are subject to strangulation because of the sharp margins of the ring. They should be opened, emptied of their contents, and removed just as is done in indirect hernia.

The technique for the usual type of sac is shown in Figure 8. The thinned and attenuated fascial fibers are cut with scissors around the entire base of the sac. This completely liberates the sac and provides a free edge of fascia for suture. The sac is then inverted and the fascial edge brought down to the inguinal ligament with interrupted sutures of fine silk. This is a mobile layer, and no tension is required for bringing it into apposition with the inguinal ligament. Fascia is approximated to fascia, and normal relationships are restored.

It is obvious, however, that the normal relationships were inadequate, or the original hernia would not have developed. Strengthening of the transversus layer is, therefore, the second requirement of the operation, and this can be adequately accomplished only by reinforcing it with another firm fascial layer which should be brought into immediate apposition with it over a broad surface, without tension and with no interposition of any other type of tissue. The reinforcing fascia may be in the form of strips or sutures, or may be a solid transplant, either pedicled or free. A flap or patch would appear to be firmer than a lattice from weaving fascial strips, and a pedicled flap possesses the obvious further advantage of retaining its blood supply and, thereby, offering better prospects of union and survival.

Pedicled flaps of firm, white fibrous fascia may conceivably be brought over the newly repaired inguinal floor from above or from below. The "white fascia" operation of Andrews brings the medial flap of the aponeurosis of the external oblique over the transversalis fascia and sutures it to the inguinal ligament. This may, in turn, be further strengthened by imbricating over it the

lateral flap of the aponeurosis. Similar fascial tissue may be derived from the anterior rectus sheath, by turning down a flap broad enough to reach to the inguinal ligament. All methods, however, of bringing the reinforcing fascia down from above have the common objection that whatever internal oblique muscle tissue is present will be interposed between the two fascial layers.

This objection can be overcome only if the reinforcing layer is brought up from below. It can then be insinuated between the internal oblique and the transversus, and come to lie in immediate apposition with the newly repaired transversus fascia. Several such methods have been described. Turner cuts a flap from the fascia of the thigh and brings it deep to the inguinal ligament to cover the inguinal area. Wangensteen turns up a pedicled flap from the iliotibial tract. This is an excellent method for repairing major defects of the abdominal wall, but he does not advise it for the routine direct hernias. For a number of years, I (14) have used a flap from the outer leaf of the aponeurosis of the external oblique to reinforce the transversalis fascia. This method is technically easy, it fulfills the requirements of a logical procedure for the problem at hand, and it has yielded sufficiently good results over this period of time to bring direct hernia definitely within the scope of operable conditions.

The technique of this method is illustrated in Figure 9. The lateral flap of the aponeurosis of the external oblique is incised obliquely downward opposite the internal ring, and the flap thus formed is brought beneath the cord. The internal oblique muscle is separated from the transversus layer and held upward with a retractor, while the flap is sutured down to the subjacent transversalis fascia. The internal oblique is then allowed to drop back into its normal position covering the suture line as a trap door. No sutures are placed in the internal oblique layer.

The final step in the operation consists in reconstructing the anterior wall of the canal. In order to obviate weakness or relaxation at the site of the incision in the lateral leaf of the external oblique aponeurosis, the cut edge is brought up under the medial flap of aponeurosis with one or two mattress sutures. This medial flap is then brought over the cord and sutured to the outer surface of the inguinal ligament. A new external ring may be fashioned by means of a pursestring suture in Scarpa's fascia.

This procedure meets the requirements of a logical repair for the usual forms of direct hernia. The aponeurosis of the external oblique is almost invariably adequate for a reinforcing flap. Only fibrous tissue is sutured to fibrous tissue, and the layers are approximated to one another over a broad surface without tension and without interposition of other tissue. Silk sutures are used throughout. The time required for the operation does not exceed that required for the usual types of repair. Since no structures are brought together under tension, there is no contra-indication to repairing both sides of bilateral hernias at one sitting. While no further follow-up studies have been made since the original description of this method, the results continue to be sufficiently satisfactory to warrant the continued use of this operation in all direct hernias, and in those old, large, neglected indirect hernias in which the therapeutic problem is essentially the same as that of direct hernia.

SUMMARY AND CONCLUSIONS

A widespread tendency exists to approach the problem of the surgical treatment of inguinal hernia from the standpoint of routine application of one or another of the standard operations, without due consideration to the actual anatomical lesion to be corrected. Unwarranted complacency as to the results of operative therapy, inaccuracy and ambiguity of anatomical description, and inadequate differentiation between indirect and direct hernias contribute to the confusion attendant upon discussions of this subject.

Indirect and direct inguinal hernias are two distinct diseases. Each is based upon a different congenital anatomical predisposition, and each produces a different type of lesion. The prognosis in the two types differs widely, and appropriately different surgical attacks are required.

Indirect inguinal hernia is due solely and entirely to the persistence of the processus vaginalis testis. In the earliest stages, this pre-formed sac constitutes the only deviation from the normal. Later, there is superimposed a secondary dilatation of the internal ring, from pressure of the hernial contents. In late, neglected, massive hernias, atrophy and attenuation of muscle and fascia converts the problem essentially into that of direct hernia.

Direct inguinal hernia is due to congenital absence of muscular support to the inguinal floor, from deficiency of the lowermost fibers of the internal oblique muscle. The transversus aponeurosis is inadequate to withstand the intra-abdominal pressure, and direct hernia results. The essential lesion is a defect in a fascial structure, due to lack of overlying muscular support.

The standard operations for inguinal hernia, consisting of the Bassini method and its numerous

modifications are not pertinent to these problems, and may be definitely injurious. Logical treatment for indirect hernia should consist of ablation of the sac and narrowing of the dilated internal ring. Direct hernia requires closure of the hole in the transversus layer and reinforcement with some type of fascial plastic procedure. An ideal operation should approximate fascia to fascia over a broad surface, without tension and with no interposed muscle or fatty tissue. If possible, the reinforcing fascial layer should retain its sources of blood supply. Methods for accomplishing these requirements are described.

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TREATMENT OF CERVICAL NODES IN INTRA-ORAL CANCER

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THERE is probably no more moot question in cancer therapy than how to treat the cervical nodes in intra-oral cancer. Not only do the methods in general vary, but the same man may change his approach as new cases with practically the same manifestations present themselves at his clinic. Thus, a study of the literature dealing with the surgical treatment of cervical lymph nodes in intra-oral carcinoma fails to reveal a definition of operability. The statistical reports are based, in nearly all instances, on all the cases subjected to a neck dissection, with little or no classification of the cervical metastases. This same condition prevails in the radiological literature regarding the treatment of the cervical nodes by irradiation. The figures are usually so massed that it is impossible to ascertain the stage of the disease that has been cured or treated by irradiation. In the surgical approach the nodes may be found to contain metastatic cancer after excision. In the irradiated cases, proof of metastases is often lacking. Only lately has the presence of cancer in nodes been proved by aspiration biopsy. This method of diagnosis is not universally used, and when utilized is adequate only when a positive diagnosis can be made microscopically. A negative report is not conclusive. The clinical diagnosis of the presence of cancer in a cervical node is notably unreliable. The error ranges from 15 to 35 per cent, that is, one-sixth to one-third of the cervical nodes presenting what appear to be signs of cancer are shown, on microscopic examination, to be hyperplastic inflammatory nodes. Some reports give even higher percentages of error. It is obvious that statistics based on unproved statements of cancer in cervical nodes are most unreliable. Moreover, the reports are most frequently based on cancer of the lip—a lesion made up of an adult type of cell, slow to metastasize, and also limited in the extent of the metastases. The scope of surgery is more extensive in lip cancer than in the intra-oral group of carcinoma. The intra-oral group of carcinoma presents somewhat different problems from those encountered in lip cancer, and only these will be considered in this discussion.

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The treatment of the cervical nodes has progressed from local excision, to radical dissection, to bilateral dissection even when no nodes were palpable, to extensive irradiation in all types of cervical manifestations. During the past few years, in many clinics, the trend has been the elimination of radical surgery, so that we are approaching the stage when the irradiation is becoming too radical to the exclusion of surgery. It is not yet time to discard all surgery in favor of irradiation. Nor can surgeons disregard irradiation therapy of the neck in certain types of intra-oral carcinoma. A narrow point of view will serve only to discredit that method which is overdone to the exclusion of the other procedure.

This presentation offers my criteria for surgery or irradiation of the cervical region in cases of intra-oral carcinoma, and all the manifestations from type and extent of the primary lesion to the general condition of the patient are taken into consideration. It is not possible to present statistics to prove all these criteria, but figures are available for those conditions which are the source of most of the arguments. The other criteria are based on clinical judgments, and there is little or no disagreement. The basis for this presentation is a consecutive series of 335 cases of carcinoma of the lateral border of the tongue, from 1923 to 1933, inclusive. In all cases the diagnosis of the primary lesion was proved by microscopic diagnosis. The proof of the diagnosis in the secondary manifestation was not uniformly proved, but this phase is explained and discussed in the related portion of this paper.

It is the purpose of this paper to discuss the manifestations sequentially starting with the control of the primary tumor and continuing throughout the several local, regional, and distant manifestations, to the general condition of the patient. The subject will be approached from a surgical point of view with the understanding that the contra-indications to surgery are the indications for radiation, except in the very advanced cases in which no treatment by surgery or irradiation should be undertaken.

Controllability of primary lesion. In this series of 335 cases of carcinoma of the lateral border of the tongue, 28 patients died of intercurrent dis-

ease or were lost before it could be ascertained whether or not the primary disease could be controlled. Of the 307 patients who survived for varying periods of time which seemed adequate to make some estimate of the primary lesion, in 64 per cent the disease was apparently controlled and in 36 per cent it was uncontrolled. Of the controlled cases, some patients have remained well for 5 years or more, many have died of local or distant metastases or concurrent disease. Of the 110 other patients showing uncontrolled disease (36 per cent), nearly all have died—some with only local persistence of the disease, but most of them with both primary and secondary disease. One patient lived many years with disease present, but it is questionable whether it was persistent disease or multiple lesions. However, this case is rated in these statistics as a failure to control the primary disease.

The cases that were uncontrolled were not limited to the advanced primary lesions. Of these 110 uncontrolled primary lesions, 69 were in an advanced state of development and 41 would be considered early or borderline. This estimate is on the basis of clinical judgment, whether the lesion was extensive, involving much of the tongue or adjacent mucosa of the mouth, or whether the growth was limited to a portion of the tongue, roughly within 5 to 6 cubic centimeters in volume. It is to be noted that 63 per cent of the uncontrolled lesions were advanced primary lesions. Therefore, a neck dissection is not indicated when the oral lesion is advanced, until the primary disease is entirely eradicated. Since 36.5 per cent of the early primary lesions persist in spite of treatment, it is more advisable to delay surgical care of the cervical region until there is an assurance that the primary lesion is controlled. This required interval of time may be devoted to moderate external irradiation, thereby obtaining some growth restraint, but not damaging normal tissue to the extent that neck dissection will be impossible.

It should be noted that not all patients with the uncontrolled primary lesions died. In this uncontrolled class were included not only those patients who showed persistent disease to death, but also those patients in whom a partial glossectomy was indicated for infection or fibrosis or both, and in whom the microscopic appearance of the tissue removed indicated that cancer cells were still viable. The conclusion must be that radical surgery of the cervical region should be delayed until the primary lesion is apparently controlled.

Extent of primary lesion. If the primary lesion involves both sides of the oral cavity—except lesions of the lip if these are included in the oral group—a neck dissection is not indicated. Such involvement may be observed in central lesions, such as those in the base of the tongue or in the soft palate, or the lesion may originate on one side and extend to the opposite side, as is frequently noted in carcinoma of the lateral border of the tongue.

In this series of cases, the extension of the primary disease beyond the midline of the oral cavity was observed in nearly 25 per cent of the cases—in the more advanced cases usually with extensive unilateral or bilateral cervical metastases.

When this disease has extended to or beyond the midline, the metastatic nodes have usually reached a stage of development well beyond operability. If there is only unilateral palpable involvement of nodes, it is quite likely that when the primary disease has so far extended that the opposite side of the tongue is involved, metastases will be manifest soon in the other side of the neck; but surgical excision is contra-indicated for other reasons: first, it is unlikely that the primary lesion can be controlled, and second, bilateral neck dissection has rarely eradicated bilateral metastatic disease. The mortality from bilateral neck dissection would most likely exceed the number of patients cured by bilateral neck dissection. There are no available statistics to prove this contention, but the mortality from bilateral dissection of the neck cannot be ignored. If the disease from the extended lesion has not been deposited in the second side of the neck, there is no need for the bilateral dissection, and if it has so metastasized, the mortality percentages from the surgical procedure will surely surpass the percentage of cure.

The percentage of cure of carcinoma of the base of the tongue is extremely small, when the metastatic cervical nodes are subjected to surgical excision. This holds even though in many cases the cells of the growth are well differentiated. Many cancers in this region are so graded. The poor results of lesions of the base of the tongue are due to the midline position of many of these growths, with consequent metastases to both sides of the neck as well as to the mediastinal lymph nodes.

Grade of primary lesion. In a recent study of all tongue lesions admitted between 1923 and 1931 inclusive, it was found that the lateral border of the tongue presented 21 per cent of grade 1 lesions, 76 per cent of grade 2 and only 3 per cent of grade 3. There was none of the transitional cell type or lympho-epithelioma in this region of the tongue, these types being limited to the base of

the tongue, where 20.4 per cent of a representative group recently analyzed were either transitional cell carcinoma or lympho-epithelioma. This type of cell as well as the central location of the lesion accounts in some measure for the poor results in the surgical treatment of metastatic nodes from carcinoma of the base of the tongue, because these types metastasize early and bilaterally, at times giving rise to distant metastases in the mediastinum, abdominal cavity, and in bone.

TABLE I.—GRADE OF TUMOR IN NEARLY 400 CASES ANALYZED 1923–1931

Location of lesions	Grade of tumor			Transitional and lympho-epithelioma—%
	Grade 1 %	Grade 2 %	Grade 3 %	
Tip of tongue	28.5	57.2	14.4	0
Dorsum of tongue	56.2	37.5	6.2	0
Lateral border of tongue	21	76	3	
Base of tongue	4	66	9.5	20.4

It is not necessary to dwell long on the criteria for neck dissection as related to the gradation of malignancy of the oral tumor. Before the degrees of malignancy were understood, the very prompt and widespread recurrence, after neck dissection, of carcinoma in the operative wound was the source of considerable consternation. This manifestation usually occurs within a few months of the surgical procedure and is not confined to any one portion of the neck, but the growth invades the skin about the scar and often infiltrates the skin to the full extent of the operative flaps. This type of infiltrative growth promptly ulcerates and because there is also recurrence in deeper regions of the neck, hemorrhage frequently occurs from early ulceration and erosion of blood vessels. Although the bleeding from the lesser vessels may be controlled by moderate pressure, the constantly associated infection increases the ulceration until there is massive necrosis of the tissues of the neck with hemorrhage from the larger blood vessels which cannot be controlled. The depletion of the patient by repeated bleeding from the erosion of even the smaller vessels decreases his resistance to bacterial infection, so that death intervenes, caused by infection as much as by carcinoma. This sequence of progressive disease is most common in the transitional cell type of carcinoma and lympho-epithelioma, and to a lesser extent in epidermoid carcinoma, grade 3. These first two types seldom occur in the lateral border of the tongue, being much more frequent in the base of the tongue, the tonsil, and the nasopharynx. The same sequence of recurrence—infiltration, ulceration with erosion of the cervical vessels—may and does occur in the more adult types of carcinoma, when ill advised or inadequate surgery is done.

Limitation of cervical metastases. The fourth in the group of criteria for neck dissection in oral carcinoma will necessarily be considered under two headings, because the indication and contra-indication are not antitheses as in the other criteria, which were discussed together. Therefore, the lesions of the lateral border of the tongue will be used for the indications, and this same group together with a larger group of all oral lesions previously reported will be used to explain the contra-indications for neck dissection.

The condition of the cervical region is classified, irrespective of the primary lesion, in 4 groups: (a) those with no metastatic nodes throughout the course of the disease; (b) those who develop metastatic nodes; (c) those admitted with operable nodes; and (d) those admitted with inoperable metastatic nodes.

TABLE II.—CERVICAL LYMPH NODES IN 335 CONSECUTIVE CASES OF CARCINOMA OF THE LATERAL BORDER OF THE TONGUE

	Cases
No nodes throughout	139
Developed nodes—operable	64
Developed nodes—inoperable	28
Admitted with operable nodes	49
Admitted with inoperable nodes	55
Total	335

The cases have been classified in Table II according to the criteria previously enumerated, except in regard to the grade of the tumor. The futility of neck dissection in the more malignant types of cancer was not fully understood in 1923, the first year included in these statistics. At that time the classifications as to the operability were based solely on the technical operability of the cervical region. The gold tubes for the interstitial application of radon into the tumor mass had not been developed at that time. These were first used extensively in 1925. As gold tubes of radon were not used in earlier years and as underdosage by external irradiation, as we now understand dosage, was the rule, an occasional case was subjected to surgical removal of the nodes which would now be assigned to radiation therapy only. Otherwise, the criteria have held throughout this group of 335 cases of cancer of the lateral border of the tongue.

In the group of 113 cases which had operable nodes on admission or developed nodes after

admission, almost equal numbers were subjected to surgery of the cervical region and to radiation treatment of the nodes. The surgical cases had microscopic proof of the metastases in all instances, but some of the irradiation cases lacked this proof. The others had an incisional or aspiration biopsy. It is not necessary to give the percentages here, because in all cases the clinical evidence seemed quite adequate. Practically all the failures gave unmistakable evidence of cervical metastases, often by fungation of the tumor. Assuming that all irradiation cases had metastatic carcinoma, even then the comparative figures should be conclusive in regard to the procedure to be followed.

Sixty-eight patients were treated by irradiation and in 45 cases a neck dissection was done. The cases for these methods were not at all times deliberately chosen. Occasionally some other disease contra-indicated radical surgery. During the latter few years a large proportion of cases purposely have been subjected to irradiation rather than surgery.

The neck dissection in practically all the surgical cases was a radical dissection. In the first year or two covered by the statistics, in an occasional case a lesser procedure was done—removal of tissue of one or two triangles of the neck. In only one case was a simple excision of nodes done. The external carotid artery was ligated for hemorrhage, and gold tubes were implanted in the wound. This case has been allotted necessarily to the surgically treated group.

Of the 68 patients with operable neck metastases subjected to irradiation, 5 remained free of disease for 5 or more years. Three of these had positive biopsies at the time of the surgical exposure for radon implantation. The diagnosis in the 2 other cases depended on clinical examination. The group so treated, therefore, had a 5 year survival of 7.4 per cent.

In the operable group in which a neck dissection was done, in 45 cases, 9 patients or 20 per cent are known to have survived free of disease for 5 years or more. In the total operable group there were 2 cases lost in 4 and 4½ years, both free of disease at the time, and both had had proved metastases in the cervical region. It is reasonable to assume that there would be no recurrence at such a late date. Though such an event might occur in lip carcinoma, it is not so in carcinoma of the tongue. There was one lost case at 4½ years in the surgically treated and in the radiation treated group. If these cases were added to their respective groups, the percentage of the operable and irradiated group is 8.8 per cent and of the surgically treated group it is 22.2 per cent. These percentage figures show considerable difference in the results of irradiation and surgery in the operable group. To get the proper estimate, these figures should be compared with each other. In doing so, it is learned that the surgical cases showed a better result by more than 200 per cent, even though there were included in the radiation group 2 cases that were not proved to have metastatic carcinoma microscopically, although the clinical evidence seemed sufficient to classify the nodes as metastatic nodes. If the non-proved cases were deleted from the statistics, the percentage of cured cases in the irradiation group would be 5.9 per cent whereas the surgical group would remain the same—22.2 per cent. These latter two percentages include the 4 and 4½ year cases. The question might be asked here why the non-proved cases were deleted from the well cases and not deleted from the failures. In the latter group there was no doubt about the presence of disease in the cervical region. The nodes progressed to a mass of cancerous nodes and often fungated through the skin. There is no difficulty in differentiating an advanced metastatic mass from inflammatory nodes in the late stages of metastases in the cervical region.

It might be maintained by the proponents of irradiation that the radiation treatment of the earlier cases was not as good as during the later years. That is granted. But because of the less efficacious irradiation by the roentgen-ray and glass seeds of radon in the first years of these statistics, some doubtful cases were subjected to surgery. These were included in the operable and operated upon group, but would now be allotted to irradiation. It is certain that these would more than compensate for the less efficacious irradiation of that period. The analysis of these two groups of cases by years has not shown any marked difference in the percentages. My first analysis from this point of view was done in 1933. Each year thereafter I have added one or more 5 year group of patients to my statistics. Up to the present time the percentage of cures by the two methods has not varied from year to year more than 2 per cent.

Although metastatic carcinoma of the neck can be cured by irradiation, as shown by the figures, the relative percentages of cures of the irradiated and the operated upon cases in the operable group leave no doubt as to the method to be employed. It may be that further experience with the more protracted external irradiation and the more accurately estimated dosage by interstitial radon may improve the result in the irradiation group.

This experience should be obtained not in the operable group but in the large number of inoperable cases, many of which are only slightly beyond operability. As these results improve, then the irradiation method may be extended to the operable cases. Moreover, there is always a small percentage of patients in the surgical group who refuse radical surgery. These may be conscientiously treated by irradiation.

If the mortality of neck dissection were high, then there might be some hesitation in its undertaking. In ascertaining the percentage mortality, to the above series of 45 operable and operated upon cases there must be added 9 cases in which neck dissection was done for supposed operable nodes, but microscopic examination proved the nodes to be inflammatory, therefore these cases are classified as having had no nodes throughout. In this total series of 54 neck dissections, there was one death, a mortality rate of less than 2 per cent. This patient died of pneumonia, but he had a partial glossectomy at the same time the neck dissection was done. It is reasonable to attribute the pulmonary infection to glossectomy rather than neck dissection. Nevertheless, it is classified as a fatality following neck dissection.

Absence of cervical metastases. Because the contra-indication to neck dissection in this criterion is not simply the opposite of the indication for neck dissection, it must be the subject for a distinct analysis.

If there are no nodes, a so called prophylactic neck dissection is not indicated. The statistics which lead to this contra-indication to dissection of the cervical region are taken from two sources —the present series of cases of carcinoma of the lateral border of the tongue and a larger group of carcinomas of all the regions of the mouth, which was previously published in 1927. There is no reason to believe that there would be any change in the percentage of even larger groups. It is quite possible that there would be fewer advanced cases as evidenced by cervical metastases, because the laity is becoming more cancer conscious, seeking advice earlier, and because present day treatment is more efficacious.

In this series of 335 cases of carcinoma of the lateral border of the tongue, 139, or 41.2 per cent, gave no evidence of regional lymph node involvement. Sixty-four patients admitted without metastatic nodes developed operable cancerous nodes during the period of observation and 28 developed inoperable nodes in the cervical region. The number of patients developing inoperable metastatic nodes would suggest a so called prophylactic neck dissection if the figures were accepted without further analysis. However, in some of the patients developing inoperable nodes, the metastases occurred bilaterally, usually from advanced and extensive primary disease, which was uncontrolled, and, therefore, on that basis, contra-indicated surgery even before the metastases manifested themselves. A few had distant metastases at the same time as the cervical metastases appeared and radical surgery would have been of no avail. An appreciable number of cases were the highly malignant type and metastasized widely—this highly malignant type is not amenable to surgery. An occasional patient declined to return for observation for a time, during which period an inoperable cervical metastasis occurred. In the last group some benefit might seem possible from a prophylactic neck dissection, but this possible benefit seems to have been nullified when the figures in Table II are examined. To attain any possible cure in this extremely limited group, it would have necessitated a radical neck dissection in 280 patients, because surgery would have been done on the 139 cases with no metastatic nodes throughout the course of the disease, in the 92 patients developing metastatic nodes, and in the 49 patients who were admitted to the hospital with the cervical region in an operable condition. A neck dissection would not have helped the 139 patients who had no metastatic nodes at any time, nor would it have made any significant change in the result of those developing inoperable metastases. The routine neck dissection would mean this: that 280 would have had a radical neck dissection, whereas only 113 could reasonably have been expected to have derived any benefit. From this group were taken the 113 cases previously discussed under indications for surgery. Others developed inoperable nodes or refused surgery. One hundred thirty-nine patients needlessly would have had a radical neck dissection. The mortality of this operation usually varies from 2 to 6 per cent. Fischel reported that, in a series of 42 cases of cancer of the lip with palpable nodes, only 14 of the nodes proved to be carcinomatous; and, in 13 cases in which there were no palpable nodes, microscopic examination showed the presence of cancer in the nodes in 2 cases. It is not reasonable to expect that the 5 year results would improve by such a percentage. To these figures may be added the thought that 139 patients would have suffered the physical and mental discomfort of a major operation from which they obtained no benefit.

Previously published by me are the following figures for a much larger group of cases of all the oral lesions.

TABLE III.—CONDITION OF CERVICAL REGION IN SERIES OF CASES OF ORAL CARCINOMA—NECK NODES IN INTRA-ORAL CANCER

Site of primary lesion	Total cases	No nodes throughout—%	Operable nodes—%	Inoperable nodes—%	Developing nodes—%
Lip	271	77.5	10	4	8.5
Tongue	268	43.3	13	14.5	28.7
Floor of mouth	122	44.2	22.5	14.5	18.8
Inferior maxilla	84	65.5	10.7	11.9	11.9
Superior maxilla	62	72.6	9.7	3.2	14.5
Hard palate	31	77.4	6.4	9.7	6.4
Soft palate	34	58.8	11.8	11.8	17.7
Buccal mucosa	98	60.2	13.3	11.2	15.3
Tonsil	124	32.3	25	22.1	12.5
Antrum	65	70.8	10.8	13.5	17.4
Larynx, intrinsic	105	69.5	5.7	15.2	3.8
Larynx, extrinsic	99	44.4	11.1	41.4	3

TABLE IV.—PATIENTS ADMITTED WITH NO CERVICAL METASTASES AND THE PERCENTAGE FREE FROM METASTASES

Primary	Admitted without nodes	No nodes throughout	No nodes on entrance and no nodes throughout %
Lip	233	210	90.1
Tongue	194	117	60.3
Floor of mouth	77	54	70.1
Inferior maxilla	65	55	84.6
Superior maxilla	54	45	84.3
Hard palate	26	24	92.3
Soft palate	26	20	77.0
Buccal mucosa	74	59	79.7
Tonsil	56	40	71.4
Antrum	54	46	85.2
Larynx, intrinsic	77	73	94.8
Larynx, extrinsic	47	43	91.6
Total	983	786	79.95

These figures in Table III show the number and percentage of the cases in regard to the condition of the cervical region on admission for all the lesions of the oral cavity. From this table are derived the figures in Table IV.

It is noted in Table IV that the lesions of the different regions of the mouth show varying percentages of freedom from cervical metastases. Several factors are responsible for this fact. Among these factors may be mentioned the mobility of the part involved, the number of lymph channels draining the part and especially the degree of malignancy with the proportionate number of highly malignant lesions of the several regions of the mouth. Comparing the figures for carcinoma of the lateral border of the tongue (Table II) this difference is not as great as it at first seems to be, because in the larger series all the regions of the tongue were included. The base of the tongue is notably likely to show early cervical metastases, especially because of the frequency of the highly malignant type of growth. To some extent these figures vary, because in the larger groups (Table IV), the percentages were tabulated for a period of only 2 years, or less if death from uncontrolled primary lesion or intercurrent disease intervened; whereas in the series of cases of carcinoma of the lateral border of the tongue all patients were followed up to the time of death—for 5 or more years in the cured cases.

Analyzing the figures in Table IV in the same manner as in Table II the figures were important. There were 1,363 consecutive cases in the group. Of these, 983 or 70 per cent were admitted without palpable metastatic nodes; 175 patients had operable nodes and 205 patients were admitted with inoperable nodes. If a neck dissection had been done on all patients except those in the inoperable group, there would have been 1,158 surgical operations on the cervical lymphatics, whereas only 372 patients had or developed operable nodes. The difference in these figures indicates the number of patients (786) on whom a major operation would have been done with little or no gain in the ultimate results.

Perforation of the node capsule. The criteria dealing with carcinoma involving or perforating the capsule of the lymph node cannot be discussed on a statistical basis, because these patients have been assigned for treatment by irradiation. This has been so for many years, because it was very promptly learned that surgery in this class of cases was futile. The rapidly growing and early metastasizing type involves the capsule early and surgery is contra-indicated because of the degree of malignancy. Other local metastases as well as distant deposits are probably present but not palpable at the time. The more differentiated types of carcinoma extend beyond the node capsule more slowly, but when the growth has so far progressed that it has invaded or perforated the capsule, the probability of eradicating the disease by surgery is most distant. Besides the possibility of more distant metastases and the uncontrol-

lability of the primary lesion, there is the added difficulty of estimating the limits of the metastatic disease. The carcinoma usually extended well beyond the palpable mass, often infiltrating an important blood vessel of the region or involving the periosteum of the mandible if the metastasis was in the upper portion of the neck. Following the infiltration of the capsule, the carcinomatous nodes seem to necrose centrally very promptly, because of the interference with the blood supply. The cavity may be very irregular in contour and may even involve the surrounding structure so that any surgical procedure will cause contamination of the normal tissue by viable cancer cells. Unsuspected involvement of the platysma muscle is often noted upon the exposure of such a node for radon implantation. The extent of the growth in this more advanced state of metastatic disease is impossible to ascertain. The sequence of events, following contamination of the operative field by viable cells from a node with a perforated capsule is the same as discussed under grade of tumor, namely recurrence, infiltration of skin, and other structures of the cervical region, followed by erosion and hemorrhage. The only variation is the greater rapidity of the progress, because of the diffuse contamination. The node capsule may be infiltrated and the node still be movable. Only after the cancer has perforated the capsule of the node does the mass become irregular in outline, merge with the surrounding tissue, and become fixed. Therefore, a metastatic node that is irregular in outline, merges with surrounding tissue, and is partially or completely fixed, does not constitute a suitable condition for radical surgery.

Extent of cervical metastases. Bilateral cervical metastases contra-indicate neck dissection. Contralateral involvement is practically the same contra-indication, because with contralateral metastases, the cervical region on the same side as the primary lesion quite certainly contains carcinoma but not in a palpable stage. The contralateral metastatic deposit may find more fertile soil, and therefore may reach a palpable stage more promptly than does the metastatic deposit on the same side as the primary lesion.

No statistics are available to show the futility of operating on bilateral and contralateral metastases, nor are there any such figures known. It may again be emphasized that published figures are the conglomerate type and include not only those cases with metastatic neck nodes but also those without metastases. These are of no value in deciding upon a procedure to be followed and in estimating the prognosis of an individual case. The criteria dealing with bilateral metastases have been considered in that portion of the discussion relating to extension of the primary growth to the opposite side of the oral cavity, and it need not be amplified here. Few surgeons now attempt the eradication of bilateral cervical metastases from oral carcinoma—except lip.

Distant metastases. It is obvious that a distant metastasis is a contra-indication for neck dissection. Such metastases occur in lungs, mediastinal nodes, liver, abdominal nodes, bones, and other less likely places. No known treatment can have sufficient influence on the disease in the more distant regions to indicate a radical neck dissection for concomitant cervical metastases.

General condition of patient. Because oral carcinoma is a disease of middle life and especially of the more aged, some consideration must be given to the life expectancy of a patient when treatment is planned. It is not possible to anticipate an acute pulmonary disease, nor some of the acute cardiac disorders, but it is possible to make some estimate of the kidney function, the condition of the blood vessels, and the state of the myocardium. Disease of the kidneys, blood vessels, and heart are the causes of many of the deaths in the aged. Unless there is a fair life expectancy for the patient, no radical surgery should be undertaken. The mental shock, the physical trauma, and the possible mortality should be considered in estimating the probable prognosis for each patient. This is a matter for clinical judgment and no rules can be formulated.

Based on the several possible manifestations, from the local lesion to the general condition of patient, the criteria may be expressed as follows:

NECK DISSECTION

Indicated	Contra-indicated
1. Primary lesion is controlled.	1. Primary lesion is uncontrolled.
2. Primary lesion is limited to one side of the oral cavity.	2. Primary lesion extends to or beyond the midline of the oral cavity.
3. Primary lesion is shown to be of highly differentiated cell type.	3. Primary lesion is shown to be of undifferentiated cell type.
4. Cervical metastases are present and limited to one group of nodes or nodes in two contiguous cervical triangles.	4. No metastatic nodes are present.
5. Capsule of nodes is not perforated by carcinoma.	5. Capsule of node is perforated by carcinoma.
6. Opposite side of neck is free of metastases.	6. Contralateral or bilateral cervical metastases are present.
7. No distant metastases are present.	7. Distant metastases are present.
8. Patient is in good general condition.	8. Patient is in poor general condition.

It should be obvious that for a case to be operable, all the indications for neck dissection must be present, and the presence of any manifestation mentioned in the contra-indications rules out a radical neck dissection.

The specific procedures to be followed in the treatment of the cervical region cannot be fully outlined. If the treatment is to be surgical only the radical neck dissection is advocated. Some surgeons of experience seem to be satisfied with a suprahyoid dissection of the neck. It is my opinion that the radical neck dissection, removing the sternomastoid muscle and internal jugular vein, together with the bloc removal of the tissue of the cervical triangles, is the method of choice. In the irradiated cases, no exact procedure can be outlined. The available facilities for external and especially interstitial irradiation vary greatly in the many clinics. The radiological approach must depend on the available radium or radon and the type of applicators. These criteria are applicable for clinics in which competent surgery is done, and in which are located competent radiologists with adequate irradiation facilities.

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AN EXTRAPERITONEAL METHOD OF REPAIRING A THIRD DEGREE PROLAPSE OF THE SIGMOID FOLLOWING A COLOSTOMY

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THE prolapse of a portion of the sigmoid following a colostomy may cause serious consequences. Although the prolapsed gut may be easily reduced, an operative repair is indicated if permanent restoration is desired. The main objection in repairing such a prolapse is the possible contamination of the peritoneum and the development of peritonitis. A procedure which completely excludes the prolapse from the peritoneal cavity is presented in this communication. Since the plastic repair is done extraperitoneally the danger of peritonitis is eliminated.

From the George Washington and Georgetown Surgical Services of the Gallinger Municipal Hospital, Washington, D.C.

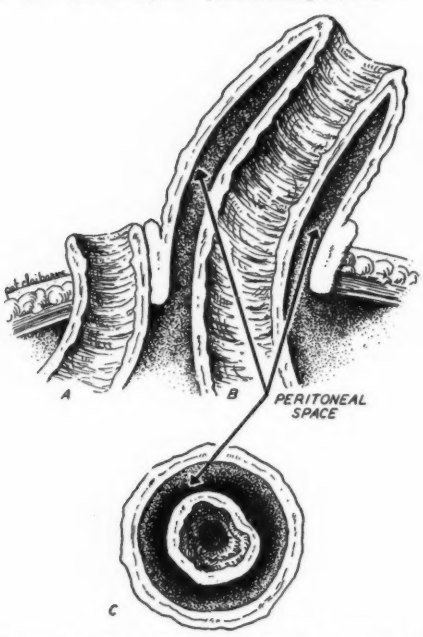

Fig. 1. Schematic drawing showing the eversion of the prolapsing segment from fixed position at the end of the loop. Note the direct communication of the peritoneal extension along the bowel with the general cavity.

Some degree of prolapse or eversion of the divided loop of bowel may follow any colostomy. It is more likely to occur in the double barrel type, because of the size of the opening in the abdominal wall through which it protrudes. The size of the defect made in the abdominal wall in the performance of a colostomy is undoubtedly the most important factor in the prevention or the creation of a prolapse of the colostomy loop. Infection around the colostomy may break down the incision and weaken the stability of a newly formed artificial anus. A long redundant segment of bowel is more prone to prolapse than a short fixed segment. Prolonged increased intra-abdominal pressure as produced by straining in attempting to defecate, or in lifting a heavy weight, may cause the colostomy loop to become everted.

One may grade the extent of the prolapse of the colostomy loop into 3 degrees as is used for rectal prolapse. The first degree is an eversion of only the mucosa. The second degree is an eversion of the entire bowel wall but to a very short distance. The third degree is an eversion of several centimeters or inches of the bowel (Figs. 2 and 3). The degree of the prolapse depends upon the size of defect in the abdominal wall, the mobility of the sigmoid, and the intra-abdominal pressure.

Besides the presence of the protruding bowel the patient complains of local pain. There may be bleeding from the exposed mucosa, and, if not reduced, ulceration or gangrene may develop. The prolapsed loop may become so swollen that complete obstruction results. While it may be possible to reduce a third degree prolapse, either by taxis or bed rest, it usually recurs. Furthermore, there is a gradual increase in the size and extent of the prolapse so that surgical removal of the external segment is indicated.

During the past 2 years at the Gallinger Municipal Hospital, we have encountered 4 cases in which a third degree prolapse has occurred in one loop of a double barrel sigmoid colostomy. In 3 instances the lower segment became prolapsed and in 1 the upper segment.

The pathological anatomy of a prolapsed sigmoid loop is similar to that of an intussusception.

Fig. 2. Third degree prolapse of lower segment of double barrel temporary sigmoid colostomy. Colostomy for relief of stricture of rectum due to lymphopathia venereum.

Fig. 3. Third degree prolapse of upper segment of permanent type of colostomy. Colostomy performed for relief of stricture of rectum due to lymphopathia venereum.

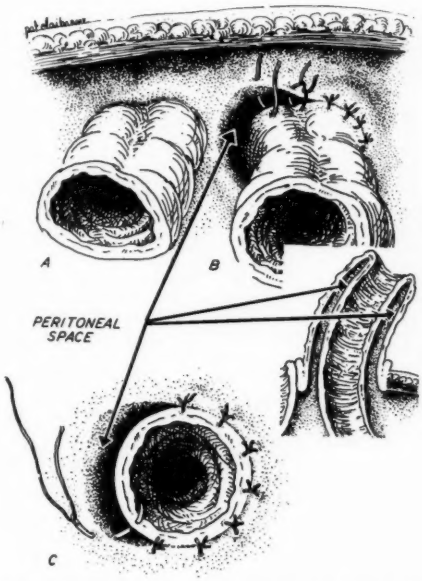

Fig. 4. First stage of extraperitoneal repair from within abdomen. A, Non-prolapsing loop; B, the prolapsing loop, showing closure of peritoneal space around fascial ring with No. 00 chromic interrupted sutures; C, cross section of closure of space around fascial ring through which loop protrudes.

The end of the sigmoid loop is firmly attached to the abdominal wall and remains fixed. Therefore, the bowel protrudes by a process of eversion. A cross section through the prolapse would reveal an outer tube with mucosa externally, a space

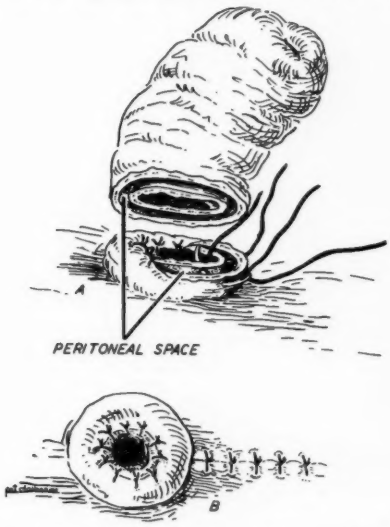

Fig. 5. Second stage of repair. A, Excision of prolapsed segment and closure of space; B, closure completed and defect in abdominal wall made smaller by the resuture of layers about the colostomy.

communicating directly with the peritoneal cavity, and an inner tube of bowel with the serosa external (Fig. 1). If one examines the colostomy from inside the abdomen, the double loop of colon will be seen extending through the abdominal wall. The opening in the wall is bounded by a hard fascial ring to which the parietal peritoneum is closely bound. In the case of a permanent colostomy the non-prolapsed segment will be found to be firmly adherent to the abdominal wall and there will be no external extension of the peritoneum. In the Maydl double barrel type the non-prolapsed segment will be firmly attached at all points except to the prolapsing segment. At this point it will be pulled a short distance through the opening along with the prolapsed loop. The prolapsed segment in the permanent colostomy may be entirely free as it passes through the opening in the abdominal wall. It may be attached along one side of the opening and free on the other. In this case the peritoneal extension will be limited to the free portion. In the Maydl type, of course, the prolapsed segment will be attached to the non-prolapsed loop on one side. The manner of attachment of the loops and the degree of peritoneal extension through the opening cannot be accurately determined until the colostomy is exposed through an abdominal incision.

The danger of producing peritonitis by resection of the prolapsed loop is obvious since it does communicate with the peritoneal cavity. The gravity of this danger was illustrated in one of our cases. From an external examination we felt that we were dealing only with redundant mucosa. This was removed with a cautery and a fatal peritonitis developed. In order to eliminate the possible contamination of the peritoneum, the following procedure has been used successfully in 3 cases.

The abdomen is prepared and draped in the usual manner with the colostomy walled off from the remainder of the operative field. A midline incision is then made at the level of the colostomy. In the case of a midline colostomy a left rectus incision should be used. When the abdomen is opened the inner loops of the colostomy are identified (Fig. 4). A finger is passed around the prolapsed loop and the extent of the defect and the limits of peritoneal extension are noted. Then a row of interrupted No. 00 chromic catgut sutures, completely encircling the prolapsed loop, are passed from the serosa of the involved bowel to the adjacent parietal peritoneum of the fascial ring. This closes the peritoneal extension along the bowel loop and excludes the prolapsed portion from the general cavity. If the sigmoid is redundant it should be attached to the abdominal wall. A slit is made through the parietal peritoneum for several inches just distal to the colostomy opening. The redundant sigmoid is then sutured into this slit by interrupted sutures. The abdomen is now closed in layers.

The second stage is carried out 48 hours later in the following manner. The prolapsed loop is divided about 3 centimeters from the abdominal wall, and all bleeders are ligated. The outer and inner bowel walls are then approximated with interrupted chromic No. 00 catgut sutures (Fig. 5). If the defect in the abdominal wall, through which the colostomy makes its exit, is too large it should be repaired at the same time. This is done by simply opening the old incision and reclosing the wall in layers making sure that a snug closure is obtained around the protruding loops.

SUMMARY AND CONCLUSION

One loop of a sigmoid colostomy may become prolapsed if the defect in the abdominal wall is too large. This defect may be due to improper closure of the abdominal wall about the colostomy or may be caused by separation of the incision following infection. Prolapse is more prone to occur in the double barrel than in the single barrel type of colostomy. Apparently the lower "non-functioning" loop prolapses more frequently than the upper functioning segment. The pathological anatomy is similar to that found in the presence of rectal prolapse. The danger of peritonitis following repair is obvious. A procedure which eliminates this danger by extraperitonealizing the prolapsed segment has been presented.

GAS CYSTS OF THE INTESTINE

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GAS cysts of the intestine are a rare and interesting condition, first described in the American literature in 1908 by Finney. He encountered the lesion incidentally while operating for carcinoma of the pylorus and noted

"... a curious, soft, multilocular cystic tumor, 15 centimeters long by 8 centimeters wide at its widest point, found attached to the free border of a loop of ileum about 1 foot above the ileocecal valve. No similar growths were observed elsewhere in the abdomen. From the peculiar cystic appearance of the mass, it was for a moment thought to be a beginning echinococcus cyst. On further examination, however, it was discovered that the cysts contained only gas. The cysts, of which there were a great many, were massed together like soap bubbles in a basin of suds, being irregular in shape on account of the pressure of the neighboring cysts. The cysts themselves varied in size from microscopic to as large as grapes. Each cyst seemed to have a thin, fibrous tissue wall of its own. Here and there hemorrhages could be seen in the fibrous tissue stroma. When the cyst walls were punctured, the air escaped with an audible hiss or pop, showing that it was under considerable pressure. The cystic growth was most prominent on the free border of the intestine, but completely surrounded the affected loop, extending here and there in scattered groups on both sides of the mesentery, for a distance of from 2 to 3 centimeters from its intestinal attachment. Some of the cysts were pedunculated. A single cyst or group of them might be attached by a single pedicle. The whole tumor mass was covered here and there by a thin, web-like fibrous structure which suggested an old fibrinous peritoneal exudate that had become partially organized. There were no adhesions between the tumor and the surrounding structures."

Finney's description of the gross appearance of these cysts is quite typical. He and Professor William Welch, pathologist, believed that the growth was a distinct type of tumor, the cells of which have the faculty of secreting gas. At the present time this theory is not generally held, although the exact etiology of the condition is still unknown. Finney brought the literature on the subject up to date and gave a synopsis of the histories of 18 cases previously reported in foreign journals.

From the similarity of the gross and microscopical pathology dating from the first case reported by Bang in 1876, there is no doubt that the condition was known as a distinct entity even at that early date. It was also known, as was proved by secondary operation in Mori's case, that the cysts may undergo spontaneous disappearance. Nine months after an operation for stomach trouble, during which he had found most of the jejunum and ileum covered with innumerable air-containing cysts, he had occasion to reopen the abdomen for obstruction and found to his surprise there was not a sign of a cyst to be seen on any part of the intestine.

A composite of the microscopical examinations of these cysts shows that they are of various sizes. They have, as a rule, a lining of endothelial cells with an outer wall of connective tissue. Within the dilated lymph spaces are numerous giant cells containing from 20 to 50 nuclei. Numerous dilated capillaries and small blood vessels are found in the fibrous tissue interspaces between the cysts. Most of the cysts are devoid of contents except air, and although they may occupy any layer of the intestinal wall, they are usually subserous.

The second report of an American case is by Turnure, of New York, in 1913. As in Finney's case, the condition was found incidentally while he was operating on a stomach lesion. Turnure gave a very complete description of his case, with pictures of the gross and microscopical appearance of the cysts. He observed: (1) The gas found within the cysts was apparently atmospheric; (2) there is an absence of communication between the cysts; (3) there is an inflammatory and productive process between the cysts, resulting in the formation of connective tissue leading to the obliteration of certain cysts and, therefore, a kind of healing process; (4) absence of bacteria in most of the cysts.

He draws attention to the fact that the formation of small gas cysts in the intestine of animals (hogs) has been known for a long time. The disease, found in an otherwise healthy hog was first described by Mayer in 1825. As to the origin of the condition found in animals, Schweitzer and Heydemann claimed that there is a certain amount of obstruction of the intestine, due to a catarrhal inflammation which causes accumulation of gas, and which under pressure is forced into the lymphatics through small openings in the mucosa, thus forming the cysts. Although Turnure discussed the pathogenesis of gas cysts from the following viewpoints, namely bacterial, mechanical, neoplastic, and chemical, he arrived at no definite conclusions concerning their origin.

Turnure cited 50 cases, including his own, and gave abstracts of each case.

From the Jackson Clinic.

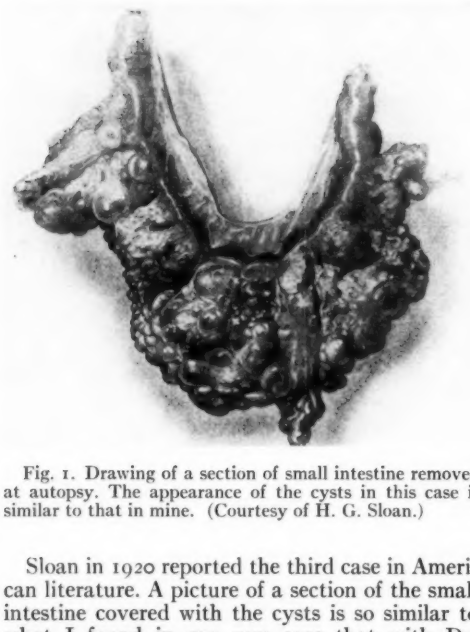

Fig. 1. Drawing of a section of small intestine removed at autopsy. The appearance of the cysts in this case is similar to that in mine. (Courtesy of H. G. Sloan.)

Sloan in 1920 reported the third case in American literature. A picture of a section of the small intestine covered with the cysts is so similar to what I found in my own case that with Dr. Sloan's kind permission I am reproducing it here (Fig. 1). He discusses the etiology and decides that the condition is best explained by the mechanical theory.

My own case, operated upon in January, 1920, would be the fourth authentic American case.

In England Nitch and Shattock reported 2 typical cases in 1919 and concluded that the balance of evidence is slightly in favor of a mechanical causation, i.e., an effusion of gas from the lumen of the alimentary canal through ulceration of the mucosa.

In 1923 they tabulated 85 authentic cases from all sources and noted that 50 to 60 per cent are accompanied by gastric or duodenal ulcer and 83 per cent have caused partial or complete obstruction.

Mills, in 1925, reports 1 case of his own and 2 others. In 1 of the latter cases, a second operation was done 2 years later, at which time the cysts had all disappeared. This fact corroborates Mori's case and my own.

In 1928, Silverstone reported a case found at operation for a perforated gastric ulcer. Approximately 3 months later it was necessary to reoperate on account of the gastric pathology, and at that time there was no trace of the cysts found, the bowel being roughened and cicatrized.

Lamont, describing an additional case in 1928, believed that "the gas is neither forced into, nor formed in, tissue spaces, but is formed in actual lymph channels. The anatomical arrangement of the lymphatics, which form a complicated series of plexuses, would be quite compatible with the tier-like arrangement of the cysts. Furthermore, the histological appearances support this view." As to how the gas is produced, he is not ready at this stage to suggest more than that he believes the gas formation is purely a chemical reaction related to the absorption of the contents of a dilated stomach and bowel. Secondarily to the gas production there is, he believes, a pathological process of perilymphangitis which results in the loculation leading to cyst formation.

Pybus reported a case in 1934. This case, like so many of the others, was encountered at operation for pyloric obstruction due to ulcer. It is interesting to note that x-ray examination showed air between the liver and diaphragm similar to Sloan's case, although no perforation was present. Both authors believed that this was of some diagnostic importance.

In 1929 Moore reported 4 cases in infants and states that up to this time only one previous case in an infant had been reported, and that by Maass.

Botsford and Kradower in 1938 described 6 additional cases in infants, bringing the total number up to date as 171. Englund's case, which they include, is probably not a true pneumatosis of the bowel.

From the description of gas cysts in infants it would seem that, grossly, their appearance is similar to that found in the adult; their location is in the mucous and submucous layers of the intestine, whereas in the adult they are usually subserous. In 3 of the cases of Botsford and Krakower, cysts were found in the mesenteric lymph glands, and in 1 the cisterna chyli and the proximal half of the thoracic duct were distended with gas. In most of the infants, diarrhea was a symptom, and enteritis and mesenteric lymphadenitis was found at autopsy; very rarely were giant cells found in and around the cysts.

CASE REPORT

Clinic No. 37210, L. L. J., a farmer, aged 53 years, first consulted me at the clinic in December, 1917, complaining of "stomach trouble." For 25 years he had noted a dull, gnawing pain in the pit of his stomach which was present most of the time and was occasionally relieved by the taking of food. For several years he had vomited from one to three times daily and the vomitus consisted of undigested food particles, some of which had been taken several days previously. There had on occasion been some blood and mucus in the vomitus. His appetite was poor, he was

constipated, and had lost some weight. All symptoms were more severe during the summer months. The family and past medical history were irrelevant; an appendectomy had been performed in 1905.

Physical examination showed a rather poorly nourished male; the heart and lungs were normal. Abdominal examination revealed marked tenderness at Mayo-Robson's point. The liver, spleen, and kidneys were not palpable, and there was no evidence of hernias. Gall-bladder x-ray films showed no abnormalities; a gastro-intestinal series showed a very large stomach with several peristaltic waves; no duodenal cap. Diagnosis: pyloric obstruction, probably due to a duodenal ulcer.

Operation was advised but the patient demurred. I next saw him on January 26, 1920, 25 months later, when he was admitted to my service at the Madison General Hospital, referred by Dr. M. W. Randall of Blue River, Wisconsin.

The history disclosed that 9 days previously a sudden, severe, epigastric pain had prostrated him. About an hour after the onset of the pain, vomiting began which had continued almost constantly. He had passed some flatus but had had no bowel movement since the onset.

Physical examination revealed his condition to be very grave. His abdomen was distended. His appearance was typical of an obstruction of several days' duration. An immediate laparotomy was performed. The small intestine was moderately distended and dusky red in color, and there was a volvulus present involving the ileum. Covering the greater portion of the intestine were innumerable cysts varying in size from a millet seed to almost as large as the end of one's thumb. In places they were found grouped together like a small bunch of grapes; they were also noted on the surface of the mesentery. Some were transparent; others presented a creamy white appearance. The cysts apparently were pneumatic, as they contained no fluid when opened.

Being unfamiliar with the condition at the time, I thought it was some type of cystic neoplasm. A specimen was removed and sent to Dr. C. H. Bunting of the pathological department of the University of Wisconsin for examination. Dr. Bunting recently re-examined the sections and submitted the following report: "The specimen consists of a series of cysts without obvious content. They are also without epithelial or demonstrable endothelial lining. Their walls consist of dense connective tissue which in most places is cell poor and fibrous, although in some regions fibroblasts are more numerous, and there are lymphocytic infiltrations. In one cyst several multinucleated, foreign body giant cells are flattened against the fibrous wall. In the angular tissue masses between the cysts there are some adipose tissue and a few arteries and veins of considerable size." A photomicrograph enlarged ten times accompanied his report and is reproduced here (Fig. 2).

The volvulus was reduced and a simple enterostomy was performed. Due to the patient's extremely bad condition, no attempt was made to examine the stomach and duodenum.

Convalescence was slow but he made a satisfactory recovery. He was not seen by me again until September 5, 1923, 2¼ years later, when he was brought to the Madison Methodist Hospital on account of abdominal pain of 24 hours' duration. The onset had been sudden and the pain severe. Needless to say, his condition was again very critical. He was vomiting, had a poor pulse, and the temperature was elevated. The abdomen was distended and rigid. The diagnosis was perforated gastric ulcer. Immediate operation was performed, and when the peritoneum was opened considerable free gas escaped. The peritoneal cavity was filled with fluid and a fibrinous exudate was present throughout. There was a perforation 1 centimeter in diameter on the anterior wall of the stomach near the pylorus, partially covered by omentum, from which air and fluid were discharging, but no food particles were present. The remarkable thing was that, nowhere throughout the abdomen could be found any sign of the gas cysts which had been so numerous at the time of his previous operation for obstruction.

Fig. 2. Photomicrograph of histological section through cysts of the mesentery.

The perforation was excised and closed with a tag of omentum covering the sutures. The abdomen was washed out with several gallons of saline and closed. The patient rallied from the operation but had a very stormy convalescence. One month after operation he had a lysis of the abdominal wound, which was closed under local anesthesia. A month after this the symptoms from his pyloric obstruction at the site of perforation were so marked that the abdomen was reopened and an anterior gastro-enterostomy was performed. This operation gave him immediate relief from his obstructive symptoms. At the time of discharge from the hospital he had a large incisional hernia.

In July, 1924, 6 months following discharge from the hospital, he reported to the clinic, complaining of pain in the left upper quadrant, thought to be due to the ventral hernia. Operation was advised but the patient refused.

Two months later he was again seen at the clinic, at which time he was still complaining of pain, locating it above the iliac crest on the left side. A colon x-ray film showed some distortion of the large bowel, which was thought to be due to adhesions. He was advised to have a repair of his ventral hernia but again refused.

In October, 1924, he decided, on account of almost constant pain in the upper left abdomen, to submit to opera-

tion, which was performed by Dr. Reginald Jackson, on October 14, 1924. His operative record showed that there was a large ventral hernia. There were extensive adhesions around the stomach and coils of intestines. The gastro-enterostomy opening was adherent to the left upper posterior abdominal wall, just below the last rib. At this point an area about 5 by 7 centimeters in diameter was very densely indurated, and was found to be a gastrojejunal ulcer which had perforated but was walled off by attachment to the parietes. The mass was freed, the ulcer excised, and a new gastro-enterostomy performed at the former site. The ventral hernia was repaired.

Pathological report by Dr. Bunting was as follows: "Section shows an ulcer with chronic inflammatory base in which there was no evidence of malignant growth." No mention was made of presence of any of the gas cysts previously described, so it is safe to assume there were none.

He was discharged from the hospital on November 3, 1924, in fair condition. He returned on March 21, 1925, still complaining of pain in left side of abdomen with considerable gas. The pain, however, was not of the burning character that he had before the removal of his gastrojejunal ulcer. There was no vomiting or hematemesis; no melena, bowels regular, no recurrence of hernia.

X-ray examination of the gastro-intestinal tract was reported as follows: "Duodenal cap not seen; stomach adherent along the greater curvature to left parietes; 50 per cent gastric residue at 5 hours. Splenic colon appears to be involved in adhesions to stomach."

He was last seen at the clinic on August 7, 1933. His complaints were about the same as they were at his last visit 8 years previously, except that a left inguinal hernia had developed. The patient did not remain for further study. In 1939 a letter from his local physician stated that he worked daily on his farm, but that he had a stricture of the esophagus which had to be dilated once or twice a year, the condition necessitating a soft diet most of the time. The patient is now 75 years old.

CONCLUSIONS

Pneumatosis of the bowel is a rather rare condition of unknown origin, although at the present time the mechanical theory is generally held by the majority of authors. My own belief is similar to Lamont's, namely, that gas gains entrance to the lymphatics at the site of an ulcer or a break in the mucosa of the stomach or bowel, and is then distributed along the lymphatics to points between the layers of the bowel walls in the form of cystic dilatations.

The condition is self-limited and eventually undergoes a fibrous tissue healing. It therefore requires no treatment *per se* when found coincident with a gastric or intestinal lesion at operation.

Although much more prevalent in adults, gas cysts have been found at operation in children, the gas having a tendency to become entrapped in the lymphatics.

My own case, operated upon in 1920, makes the fourth American case, and brings the total collected from all sources to 172.

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INJURY TO THE FEMORAL ARTICULAR CARTILAGE BY THE MEDIAL MENISCUS

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INJURIES to, and derangements of, the semilunar cartilages of the knee joint are of frequent occurrence. It is our desire at this time to describe a lesion of which we have been unable to find any previous description.

This lesion was first noted by one of us (A. DeF. Smith) in 1931 while doing an exploratory arthrotomy for an internal derangement of a knee. During the past 9 years, at the New York orthopædic Dispensary and Hospital, it has been observed as the sole finding in 10 different patients. The last case is too recent to include in this communication, so that 9 are herewith reported. It has been noted in each instance during the course of an arthrotomy which was done because of suspected injury to the medial meniscus. The symptoms and signs are similar to those encountered in tears or gross displacements of the medial meniscus. Four different operators have independently noted the lesion while exploring the interior of a knee joint. These 9 cases disclosed only the pathology to be described, although in each a long medial incision was made, thus giving an adequate exposure of the joint. Other cases have been encountered but have been excluded from this report because they were complicated by additional lesions in the knee joint. The lesion is a well defined depression in the articular cartilage of the medial femoral condyle which corresponds in position and outline to the anterior portion of the medial meniscus. Converging upon this area is a pannus of vascular tissue which encroaches upon the femoral cartilage. We believe that this lesion is caused by an injury in which the meniscus is suddenly and forcibly pressed against the femoral articular cartilage with the knee in extension. Since in none of the cases was the meniscus torn or otherwise damaged, it is probable that the mechanism of this injury is different from that which commonly causes a tear of the meniscus.

Normally there is a slight impression on the articular surface of the medial femoral condyle which is made by the anterior border of the medial meniscus. This slight impression is termed the medial groove. The medial groove normally receives the anterior border of the medial meniscus when the knee is extended. In the 9 cases reported, a sharply outlined depression was seen in the normally smooth surface of the articular cartilage overlying the medial groove of the medial femoral condyle. With the knee extended, the anterior portion of the medial meniscus fitted perfectly into this depression in the articular surface of the medial femoral condyle. A film of vascular tissue extended from the inner side of the medial femoral condyle down to the abnormal depression in the cartilage. The femoral articular cartilage was not lacerated or detached, and the underlying bone was not exposed. The articular cartilage covering the depressed area was thin and in some cases contained small areas of calcification.

This lesion does not have the appearance, usual location, or characteristics of osteochondritis dissecans, and is not to be confused with it. No loose bodies are present. The medial meniscus is not torn, and is seen to occupy its normal position. In 7 of our 9 cases, the operator described the medial meniscus as being more freely movable than normal, but in no case was there a gross displacement. The synovial membrane lining the medial aspect of the knee was moderately thickened and inflamed in 6 of the cases. Tissue sections revealed a chronic synovitis in 3 of these. Several knees presented a slight to moderate effusion at the time of operation. In all 9 cases the medial meniscus was removed, and the surgeon and pathologist could find no evidence of a tear.

ANALYSIS OF NINE CASES BEING REPORTED

There were 4 males and 5 females. Their ages at operation ranged from 16 to 48 years, with an average of 24 years. All gave a definite history of injury. Eight sustained a twisting injury to the knee, and the ninth lost consciousness at the time of injury (automobile accident). None of the patients was certain about the position of his knee when it was injured. The time interval between the original injury and operation ranged from 1 month to 24 months, with an average of 9.5 months. One patient experienced periods of

From the New York Orthopædic Dispensary and Hospital.
Read before the Orthopedic Section of The New York Academy of Medicine on February 16, 1940.
Dr. King, Annie C. Kane fellow.

Fig. 1. Lesion of articular cartilage of medial femoral condyle.

disability following minor twisting injuries to the knee, and a second patient experienced 3 such periods of disability prior to operation. In the remainder the disability was continuous from the time of the injury to the operation. All cases developed an effusion immediately following injury. This was slight to marked and lasted from a few days to a month. Pain was complained of by all patients. This was described as being over the medial aspect of the joint line just behind the medial patellar border. Tenderness was elicited in all cases and corresponded to the site of pain in each instance. Prior to operation, 4 knees presented limitation of extension—limitations of 10, 10, 15, and 60 degrees, and 7 presented limitation of flexion—limitations of 5, 10, 15, 15, 40, 45, and 45 degrees. Only 1 of the 9 cases gave a history of transitory "locking" of the knee, and this was always reduced by the patient himself. All patients experienced a sensation of instability of the knee, which was noted chiefly when climbing or descending stairs. One patient, the same whose knee "locked," experienced an actual "giving way." Three patients noted "catching," "clicking," "slipping," or "grating." All 9 patients were treated by exploratory arthrotomy and excision of the medial meniscus after conservative treatment in the form of bed rest, heat, massage, and a snug compression bandage had failed to relieve symptoms. All were relieved of the pain, tenderness, instability, and other symptoms of which they complained before operation. A woman who was 48 years old, and whose motion was limited from 80 to 170 degrees, reported a slight residual limitation of flexion after operation. A girl 16 years of age had some pain in her knee during cold weather, but had no limitation of motion or disability. Another patient had return of pain and tenderness on the inner side of the knee after spraining her ankle.

This lesion in all probability may have been noted by other operators, but in a survey of the voluminous literature dealing with medial meniscus injuries, we have come upon only the following observations. Henderson (13) stated that it is very difficult to estimate the amount of trauma that may be inflicted upon a joint surface by a crushing force exerted on attempted extension of the knee by a curled or crumpled up semilunar cartilage. Owing to its fibrocartilaginous nature, the semilunar cartilage may itself escape any serious damage and yet severely injure the cartilaginous articular surface. Bristow (2) noted erosion of articular cartilage with or without injury to, or displacement of, the semilunar cartilages in addition. Muller (17) noted that cartilaginous softening may take place at pressure points where menisci or other structures are situated, and that pressure from one structure may produce changes in the other. Chaklin found that in rare cases there was observed a combination of injury to the cartilage and to the medial meniscus. Darrach (6, 7) stated that the articular cartilage covering the femoral and tibial condyles and the under surface of the patella frequently is injured and softened. The milder lesions he considered to be often associated with an abnormal meniscus, fat tabs, or loose bodies. Morris believed that the pressure of a twisted or folded semilunar cartilage might cause erosion of the articular cartilage on the femoral condyle or the upper aspect of the tibia. Eaves and Campiche noted that in the condition described by the French as a *pincement de ménisque* (pinching of the meniscus) there is no rupture of the cartilage and no displacement of fragments, but simply a contusion with subsequent swelling of the semilunar cartilage.

The mechanism of injuries to, or displacements of, the medial meniscus is an interesting study, and various causative theories have been advanced by different authors. Sir Robert Jones called attention to the attachment of the medial meniscus along the whole of its convex margin

to the joint capsule and to the strong, somewhat fan-shaped internal lateral ligament. The anterior cornu is attenuated and its attachment to the tibia is never very strong and is often very slender. The function of the menisci is to assist the opposite lateral ligaments to resist lateral movements of the knee. They act as wedges between the tibia and femur and make the cruciate ligaments more tense. The cause of the injury to the medial meniscus he regarded as a strain thrown upon the internal lateral ligament while the knee is flexed and the femur rotated inward. Many observers (2) have noted that the coronary ligament attaching the medial meniscus to the tibia is approximately 6 millimeters in width, while that attaching the lateral meniscus is 10 millimeters in width. This, of course, limits the normal mobility of the medial meniscus, and predisposes it to pinching injuries. Galeazzi stated that fibrous bands connect the anterior crucial ligament to the anterior horn of the medial meniscus. In semiflexion, rotation movements of the knee may cause excessive tension on the crucial ligaments which is transmitted to the semilunar cartilages, and so may produce a variety of lesions. Cubbins and Conley noted that the semimembranosus tendon is firmly attached to the medial meniscus. If the leg is rotated outward, this tendon will be subject to greater tension and might press the medial meniscus deeper between the bones, so that it would be much more liable to be trapped upon sudden extension. Bernstein stated that the inner alar ligament as a rule is wider than the external and can be traced through the fat pad sending fibers which blend with it and descend to become incorporated or inserted with the coronary and transverse ligaments into the anterior cornu of the medial meniscus. Sudden contraction of the quadriceps tendon pulls the patella with a violent jerk, pulling the anterior cornu of the medial meniscus away from the region of safety by means of the internal alar ligament. Love believes that during the outward rotation of the femur on the tibia the associated movement of the more mobile lateral meniscus is transmitted by the transverse ligament to the anterior horn of the medial meniscus. Henderson (14) found that some fibers of the quadriceps are inserted rather low down on the inner side of the capsule. He felt that this prolongation, on attempted extension, might pull in such a manner as to disturb the normal contour of the medial meniscus, thus causing its anterior extremity to be caught between the femur and the tibia. He also believed (15) that there was such a condition as a hypermobile medial meniscus which moves about enough to be pinched occasionally but not fractured. However, Surls and Osgood thought that when the quadriceps contracts it extends the joint and at the same time draws the capsule tense. The capsule transmits this pull to the menisci, and draws them up out of harm's way as the joint is extended; when the quadriceps relaxes, it allows the knee to flex and the menisci to slide centrally again.

Most observers (17) have felt that roentgenograms of these knees, which at operation present medial meniscus pathology alone, are negative save for some narrowing of the medial compartment of the joint space in long standing cases, and effusion in the more acute cases. In the anteroposterior view we have at times noted a thickening of the soft tissue capsular shadows overlying the medial aspect of the joint line. This may be seen not only in the lesion here described, but also may be seen with tears and displacements of the medial meniscus. McIlhenny noted a haziness or blurring about the internal articular portion of the tibial head in the anteroposterior roentgenogram.

CASE REPORTS

CASE 1. F. McR., No. 133,216. Patient, a female, aged 20 years, fell from a ladder, 19 months prior to admission, and twisted her right knee. Marked effusion occurred and pain and tenderness were present over the medial aspect of the knee at the joint line. The knee felt insecure when she descended stairs. Symptoms were not relieved by conservative treatment, and on February 26, 1931, the right knee was explored. The lesion previously described was found, and medial meniscectomy was done. Examination on April 5, 1932, 14 months after operation, revealed full motion at the right knee. Only slight superficial tenderness about the operative scar was present. No instability was experienced. The knee ached slightly after prolonged walking, but the pain complained of before operation had been relieved.

CASE 2. J. S., No. 157,023. Patient, a male, aged 20 years, had twisted right knee, 2 years prior to admission, while playing baseball. Effusion, pain, and tenderness subsided after 3 weeks of conservative treatment. Three subsequent similar attacks, brought on by minor traumas, occurred. Between attacks the left knee felt insecure and unstable, and flexion beyond 65 degrees was painful. Exploratory arthrotomy and medial meniscectomy were done on January 17, 1933. Examination on October 18, 1939, 6 years and 9 months after operation, revealed no tenderness or limitation of motion of the right knee which was stable and symptomless.

CASE 3. B. H., No. 158,645. Patient a female, aged 18 years, wrenched left knee while tobogganing, 1 month prior to admission. Effusion, pain, tenderness, instability when climbing stairs and a sensation of "slipping" resulted. Motion at the left knee was limited from 165 to 40 degrees. On March 16, 1933, exploratory and medial meniscectomy were done. Examination on October 12, 1939, 6 years and 7 months after operation, showed complete range of motion of the left knee. There was no tenderness or instability, and normal function had resulted.

CASE 4. K. B., No. 167,481. Patient, a female, aged 48 years, injured her left knee, 2 months prior to admission, by losing her balance as she stepped off a high train step. Effusion, pain, tenderness, and a sense of insecurity resulted. Motion was limited from 170 to 80 degrees. Conservative treatment failed to give relief, and on May 12, 1934, exploratory arthrotomy and medial meniscectomy were done. Examination on October 15, 1939, 5 years and 5 months after operation, revealed a few degrees limitation of flexion, but no other abnormality. All symptoms of disability of the left knee had been relieved.

CASE 5. F. W., No. 186,629. Patient, a male, aged 32 years, injured his right knee 5 months prior to admission, in an automobile accident. Effusion, pain, tenderness and a feeling of instability resulted. Motion at the right knee was limited from 120 degrees to 80 degrees. Exploratory arthrotomy and medial meniscectomy were done on October 25, 1935. Examination on October 23, 1939, 48 months after operation, revealed full motion at the right knee. No abnormal physical findings were present. Except for slight aching in damp weather, no symptoms were complained of. No instability or tenderness was present.

CASE 6. L. S., No. 165,371. Patient, a female, aged 23 years, wrenched the left knee, 1 year prior to admission, when thrown to floor by a boiler explosion. Effusion, pain, tenderness, a feeling of insecurity and "clicking" were not relieved with conservative therapy. Flexion was limited to 50 degrees by pain over the medial aspect of the knee. Exploratory arthrotomy and medial meniscectomy were done on April 19, 1937. Examination on October 25, 1939, 30 months after operation, revealed motion at the left knee to be complete. Examination was within normal limits, except for a slight hypesthesia over the skin area supplied by the infrapatellar branch of the saphenous nerve. The only complaint was slight aching with damp weather. No "clicking" or instability was noted.

CASE 7. E. S., No. 214,016. Patient, a female, aged 24 years, caught her heel on a step and wrenched her left knee, 5 weeks prior to admission. Effusion, pain, tenderness, instability, and a "slipping" sensation resulted. Extension to 180 degrees caused pain and spasm. Exploratory arthrotomy and medial meniscectomy were done on June 20, 1938. Examination on October 15, 1939, 16 months after operation, revealed no tenderness, limitation of motion, or instability. Following a fall in which she sprained her left ankle on January 22, 1940, she had some pain and tenderness on the inner side of her knee.

CASE 8. F. D., No. 214,510. Patient, a male, aged 21 years, twisted his left knee 1 year prior to admission. Effusion, pain, tenderness, instability, and frequent attacks of transitory "locking" which were easily reduced by the patient, were not relieved by conservative treatment. Exploratory arthrotomy and medial meniscectomy were done on September 14, 1938. Examination on October 23, 1939, 13 months after operation, revealed full motion at the left knee. No instability, tenderness, or restriction of free motion was present. Five degrees' lateral relaxation, which had been present before operation, was still present. His only complaint was slight aching after prolonged standing, due probably to the lateral relaxation.

CASE 9. S. M., No. 222,122. Patient, a female, aged 16 years, wrenched the left knee, 7 weeks prior to admission, and sustained effusion, pain, tenderness, and a feeling of instability. Motion was limited from 170 to 70 degrees by pain and spasm. Exploratory arthrotomy and medial meniscectomy were done on May 2, 1939. Examination on October 15, 1939, 5 months after operation, disclosed no tenderness or limitation of motion of the left knee. On February 1, 1940, a moderate degree of pain upon descending the stairs was complained of, although the patient played badminton without symptoms. Crepitus was present on full flexion of the knee.

SUMMARY AND CONCLUSIONS

In 10 patients who complained of pain, stiffness, and disability of the knee following an injury, a lesion consisting of a depression in the articular cartilage of the medial femoral condyle with a pannus of vascular tissue converging upon it, was found. Although the knee was explored through a long medial incision, no other pathological condition was found and the area of damage to the femoral articular cartilage corresponded with the position of the anterior end of the medial meniscus when the knee was extended, and we believe that it was caused by an indentation by the meniscus when the knee was forcibly extended. The theory that the depression in the cartilage is caused by trauma is supported by the fact that in all the cases a veil or pannus of vascular tissue converged from the inner side of the femoral condyle upon the indentation in the cartilage.

Treatment consisted in exploratory arthrotomy and medial meniscectomy. In none of our cases was diagnosis made before exploratory arthrotomy, because the history, signs, and symptoms were identical with those of medial meniscus tears. In 10 such cases patients have been so treated at the New York Orthopædic Dispensary and Hospital during the 9 year period 1931 to 1939 inclusive. Nine of these patients have been followed-up from 5 months to 6 years and 9 months after operation, with an average follow-up period of 3 years and 3 months. The results have been most satisfactory, in that the signs and symptoms of disability complained of before operation have been completely relieved in 7 cases and greatly improved in 2 cases.

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EDITORIALS

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UROLOGY IN CHILDREN

AMONG the many notable and outstanding contributions to American medicine, the development of urology in children takes high rank. It can be said in all truth that nowhere else has this subject received such intensive study as in this country. This particular field has been greatly benefited by widespread and intensive study. Evidence of this fact is that our conception of urinary disorders in infancy and childhood has undergone a complete change, lesions which formerly were regarded as relatively frequent are now found to be relatively rare whereas, other lesions which were considered to be rare have been demonstrated to be relatively common.

One of the pioneers in the development of urology in children was the late Edwin Beer. If not the first, he was among the first to use an electrically lighted instrument to examine these little patients. For this purpose he used the Hayes pharyngoscope and to this he later attached a device by means of which the ureters could be catheterized. The great difficulty in the early days was that cystoscopes of small caliber were not available. With the development of better and smaller instruments, however, it is now possible to examine boys as young as 7 days of age with a plain examining cystoscope. The early prevailing impression that cystoscopic examinations should not be carried out in children because of the possible severe reactions, is a notion that has been practically dissipated, as it is now a well recognized fact that children tolerate instrumentation far better than do adults.

As interest in the subject grew, the necessity for following a definite routine in study was more generally appreciated. The value of a careful study of the past history and careful physical examination, urinalysis, bacteriological study of the urine, roentgen-ray examinations of the genito-urinary tract, the use of the cystoscope and ureteral catheter, the shadowgraph catheter, retrograde pyelography and cystograms has become increasingly more and more appreciated. Recently the addition of intravenous urography to our armamentarium has definitely established the fact that these children can and should have the same benefits of modern urological study as do adults. In every properly conducted children's hospital today, there is to be found a urological department well equipped and well manned.

The literature of not long ago contains numerous articles dealing with the subject of cystopyelitis and its treatment, and the long list of drugs recommended in its treatment is astounding. The very multiplicity of the therapeutic measures suggested and advised over the years, is proof positive that the de-

sired result was not obtained. Failure was and is due to the fact that in many of these cases, something more than a simple infection is present, since the causative factor is obstruction. It is an undeniable fact that obstructing uropathies in children occur with relatively great frequency. For this reason medical management should not be continued over too long a period of time before a careful urological study is made to determine why the infection persists and why the therapeutic measures instituted have failed. No matter how simple the case may be, the infection must be combated not only until the patient is free of all symptoms but until the urine is free of pus and, still more imperative, until the urine is sterile on culture. This fact was emphasized by Helmholt and myself as early as 1920.

Valves in the prostatic urethra, median bars, and contractures of the internal urethral orifice with the development of severe hydroureters and hydronephrosis are found with increasing frequency. Therefore, it is important that the underlying causative factor in each case should be discovered and corrected.

It is important that one should not lose sight of the fact that acute infection is often superimposed on serious organic lesions, and that even with the many new chemotherapeutic agents now available, one is not justified in treating patients indefinitely without instituting a careful survey of the urinary tract to determine the cause of failure of the agent employed.

The common malignant tumor of the urinary organs in infancy and childhood is the Wilms' tumor, the so called adenomyosarcoma of the kidney. Recent literature reveals many articles dealing with this condition which is of great interest not only to the urologist, but to the pediatrician, the roentgenologist, and the pathologist as well. It is to be hoped that as a result of this great interest the little patients thus afflicted will be given treatment at a much earlier period than they have been previously. Early diagnosis is just as important in the management of such cases as it is in malignant disease in the adult.

A slight difference of opinion still exists regarding the treatment of patients with Wilms' tumors. The opinion prevailing is that the tumor is radiosensitive and that a course of deep roentgen-ray reduces its size. While in general this is true, I have seen several Wilms' tumors which did not respond to roentgen therapy. Among the urologists however, it is generally agreed that a patient with a Wilms' tumor should have the benefit of preliminary deep roentgen-ray therapy. The great advantage of roentgen therapy is that often the tumor thus treated is reduced in size, and that the operation is practically safe; a fatal outcome is exceedingly rare. It is the consensus among urologists that the preliminary course of roentgen-ray therapy should be followed by nephrectomy, and that a postoperative course or radiation should be given.

Congenital anomalies of the kidney are now recognized more frequently than formerly, for now an intensive urological study of all children with urinary tract infection is made. A chapter gratifying in urology and one that should not go unrecorded is that today corrective procedures are instituted early rather than late, and for this reason it is found that destruction of the kidney by back pressure is prevented.

Careful, or rather painstaking, urological study is the order of the day. No justification can be found today for treating these patients for indefinite periods of time without carrying out such a study.

HERMAN L. KRETSCHMER.

TREATMENT OF FRACTURES A SPECIAL PLEA FOR THE TEACHING OF PRINCIPLES

MODERN treatment of fractures presupposes a knowledge of the structure and mechanism of the human body. The surgeon can only aid and abet the natural defensive and recuperative powers which are inherent in living tissue. As Hilton stated, a surgeon has no power to repair directly any injury; his chief duty is to ascertain and remove those impediments which obstruct the reparative processes and restore the parts to their normal condition. He regarded physiological rest as the most important means of accomplishing this. The therapeutic value of physiological rest was never more emphatically advocated than by Hugh Owen Thomas, whose genius devised splints which permitted enforced, uninterrupted and prolonged rest.

Recently I had occasion to conduct an examination which included questions on the principles of treatment of fractures. I found an impressive knowledge of technical detail of not only one but many methods for the treatment of a fracture. Unfortunately, however, the reasons for using certain procedures in the course of treatment were not known. I feel that there is a need for more emphasis, particularly in teaching, upon anatomical and physiological principles underlying the treatment of fractures.

The surgeon should know that it is his duty to assume apposition of the osseous fragments. The slogan, "splint them where they lie," means that displacement of fragments may be prevented by splinting the fracture before moving the patient. Effusions of blood into the tissues and increase of tissue fluid in the region of the injury are normal reactions that make for swelling. Furthermore, an irritation of the afferent nerve occurs at the site of the injured part. This sets up a reflex spasm, which is nature's attempt to obtain rest. It is much simpler to reduce a fracture before this swelling and muscle spasm have occurred; therefore, the principle holds that a fracture should be reduced as early as possible after the injury.

When fragments are displaced the surgeon must appose the ends of the fractured bone. The displacement may be due to direct trauma, or usually, to the contraction and spasm of the muscles. There may be interposition of soft parts between the bony fragments. Since reflex spasm occurs with movement between the fragments, anesthesia is essential in the relief of the spasm and an aid in the reduction of the fragments. Traction and manipulation as demonstrated by their most expert exponent, Sir Robert Jones, have proved an excellent method of reduction in certain types of fractures. Traction and countertraction are the most useful methods for correction of displacement. Mechanical traction by means of a machine such as a pulley and weights, or by a spring, is more satisfactory than by muscular pull of an assistant, since muscular fatigue makes constant, equal, and even pull difficult. In this connection an excellent rule is to place the distal fragment in alinement with the proximal fragment. To relieve muscle tension, the articulations above and below the site of the fracture must be put in the midposition or in the neutral position. This semiflexed position approximates the muscle attachments and thus relieves the tension. Direct or skeletal traction is an efficient way of obtaining axis traction. With the extremity in the position of relaxation and axis traction properly applied, shortening and angulation are obviated and this also usually takes care of interposition of muscles. More important than exact reduction is proper alinement of the fragments.

The method of choice for reduction varies in the individual fracture with the age of the patient and to some extent with the technical ability of the surgeons. Certainly the surgeon should be adequately trained so that he can choose the technique best suited for the individual case. More difficult than reduction is retention of the fragments in position, or fixation.

Fixation can be accomplished by continuous traction and, in some cases, this is the method of choice. Fixation also can be accomplished by plaster-of-Paris cast. This requires an exact technique, one that will not permit interference with circulation. Pins or wires may be inserted in the fragments, above and below the fracture line, and these are incorporated in a plaster-of-Paris cast which gives a more exact fixation. Internal fixation by means of bone plates or nonelectrolytic metallic plates (vitallium) is a method of choice in certain types of cases and is an established method of treatment since the time of its great advocate, Sir Arbuthnot Lane.

The third great principle in the case of fractures is to re-establish normal function of the injured part. A technique of treatment that will permit carrying out normal function of the part and at the same time assure fixation of the fragments will be the technique of choice, as has been proved by the excellent work of Lorenz Boehler. This is in accordance with the Hunterian principle, which is that the power to regain function is a property of the patient's will and brain. There is a period, as M. David showed, in the time of healing when absolute rest is essential and movement is injurious. There is also a time in the healing of a fracture when movement is beneficial. Recently Mason and Allen demonstrated this with controlled experiments for healing of severed tendons. A similar experiment should be done for the healing of bones. When the time has been established experimentally, variability in healing qualities such as those due to age and differences in the functional demand of the bones in the body must be taken into consideration. The fracture must show osseous union and normal use of the part must be restored.

With the discontinuation of fixation, after-treatment, as we commonly think of it, is initiated. In a dependent limb in which there is bony union, the removal of support would be followed by swelling. This swelling can be controlled by the use of an Unna paste boot, elastic bandage, periodic elevation of the limb, or all of these methods may be used in turn. Massage is of value. Light massage has a sedative effect; it decreases the pain and tends to decrease the swelling. It improves circulation of the lymph and blood of the part. Some effects of massage are obtained, as Mennell pointed out, by its effect on the reflex mechanism. The after-treatment also includes graduated and controlled exercises. Active movement is the exercise of choice. No one appreciates more the importance of voluntary effort as an exercise than the industrial surgeon. The best type of exercise is the carrying out of normal function. Since the structures have been weakened, the exercises must be directed so that they stay within the limits of the individual's capacity. Gradually, as the capacity increases, the exercises, too, can be increased.

In the case of a fracture of the calcaneus, for instance, reduction must be followed by fixation. Early weight-bearing and functional use prevent muscular atrophy, improve circulation, and stimulate formation of callus. Fixation results in a decrease in strength. Weakness of the foot leads to pes valgo-planus. This condition is counteracted by bringing the heel in valgus and the anterior part of the foot in pronation. Re-education of

normal gait is then started. The amount of use gradually is increased until the individual carries out light duty. The patient continues with light duty exercises and physical therapy until normal capacity is re-established, when he returns to full duty. Any technique in accordance with these principles will, if it is executed accurately, give the optimum result.

Treatment of fractures, therefore, presupposes a thorough knowledge of the structure and mechanism of the human body and an intelligent application of the anatomical and physiological principles. Students should be taught why a method of treatment is recommended as well as the technique for executing such a method of treatment.

EMIL D. W. HAUSER.

TEXTS AND DOCUMENTS

THE FIRST ANESTHESIA RECORDS (CODMAN, CUSHING)

HENRY K. BEECHER, M.D., Boston, Massachusetts

WITH the rapid development of anesthesia in recent years, it is easy to lose sight of the fact that as the modern specialties go this one is old, with its origins in the first half of the nineteenth century. The introduction of anesthesia into the clinic altered the practice of medicine perhaps more than any other single advance; so it is of some interest to keep the historical account straight by recording the specific steps in the progression of the specialty when they can be identified, even though they be minor ones.

It has been said that record keeping, the description and charting of the patients' course during anesthesia and operation, began in 1915. Since detailed anesthesia charts in the files of the Massachusetts General Hospital antedate 1915 by more than 20 years, it is of interest to record the fact that many of the Massachusetts General Hospital records bear the dates of 1894 or 1895. By that time two types of charts had been devised for the purpose and were in use.

The later eminence of those who were concerned with this early record keeping adds to its interest. The details can be described by the letters of those who were responsible for the records. First, there is the letter from Dr. Codman to Dr. Harvey Cushing. This letter accompanied a collection of the early charts.

"Feb. 9th 20.
227 Beacon Street
Boston

"Dear Harvey:

"Having nothing better to do lately I have been trying to put my effects into order again after the volcanic dislocation caused by the war and incidentally by the renting of our house.

"Katie, after my departure dumped all the accumulations of years into one pile. So during this snowy week I have had old diaries, letters and unpublished attempts at 'papers,' and mercilessly put them in the wastebasket. There are many things which remind me of you and show the stimulus you were to me. I am sorry that age now prevents me from reacting to your enthusiasm, and that I have ceased to cultivate my mind enough to follow your soarings in Pituitary realms.

"One of the things I cannot bear to dump in the wastebasket is a collection of ether charts which we made 30 years ago! In connection therewith I find a long *unpublished* paper on 'Etherization,' in which I described *vividly I think* but somewhat tediously the process as we then knew it. I must say I have never read anything better on the subject. I recall that the reason for not publishing it was, that I took it to 'Coll' Warren, who regarded it as too frank for the good of the hospital, for it described in detail the case which I lost in the A. R. because I was paying attention to some tomfoolery which *you* (who had come in from the theatre), were entertaining us with, while the poor devil was inhaling vomitus! I also spoke of the case which stopped breathing under ether and interested you in Brain Surgery.

"So I send you these charts to destroy with some solemnity for you and I are the only persons that give a ——— for them. Do they give less ether per hour now?

Sincerely
[Signed] E. A. CODMAN."

"Peter Bent Brigham Hospital,
Boston, Mass.
February 10, 1920.

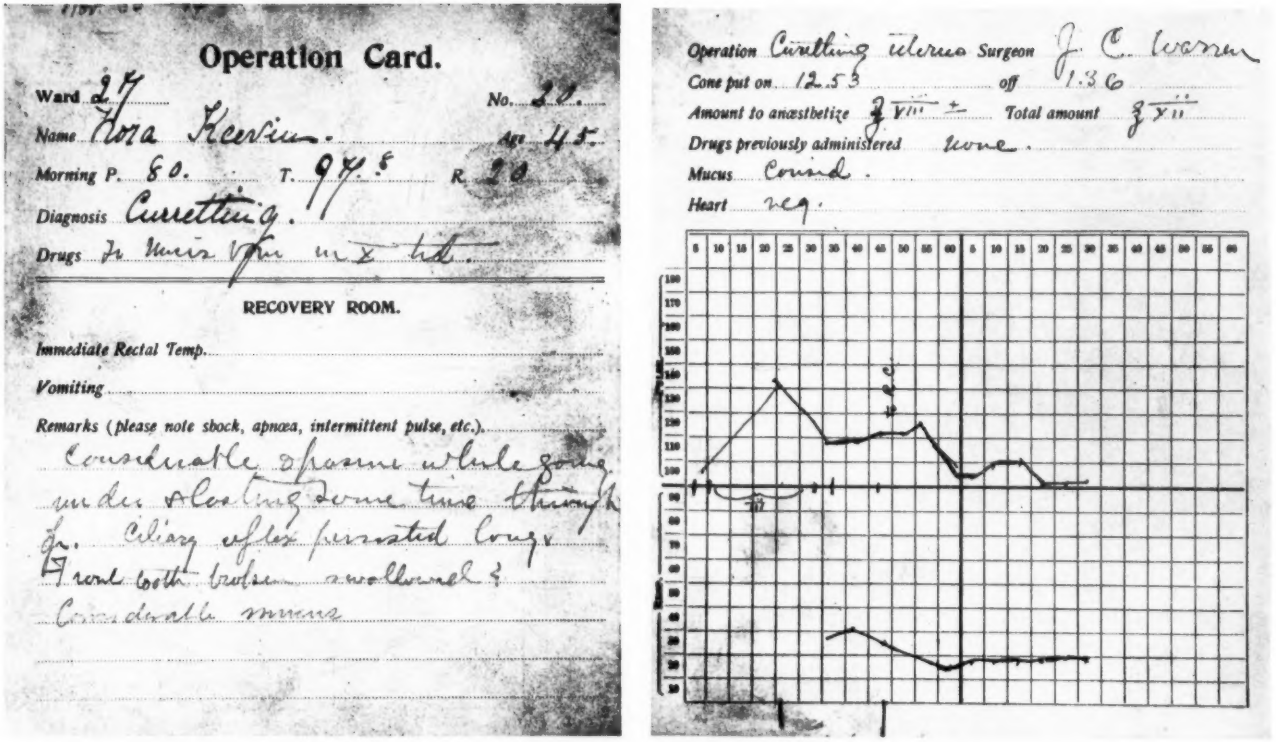
"My dear Dr. Washburn:

"I have just received the accompanying note [the preceding] from Dr. Codman with these old ether charts of the year 1895. So far as I am aware they represent the first attempt made anywhere to keep charts during anesthesia, and the story is as follows:

"When Dr. Codman and I, having entered the hospital together,[1] were 'Junior House Pupils' I believe was the official term, or 'House Pups'

From the Anesthesia Service, at the Massachusetts General Hospital.

[1] Dr. Codman preceded Dr. Cushing by about 8 months.



Operation Card.

Ward 27 No. 20.
Name Flora Keevin. Age 45.
Morning P. 80. T. 97.6 R. 20
Diagnosis Curetting.
Drugs Tr Nucis Vom m x tid.

RECOVERY ROOM.

Immediate Rectal Temp.
Vomiting
Remarks (please note shock, apnœa, intermittent pulse, etc.).
Considerable spasm while going under ether some time through it. Ciliary reflex persisted long. Vomited both times swallowed? Considerable mucus

Operation Curetting uterus Surgeon J. C. Warren
Cone put on 12.53 off 1.36
Amount to anæsthetize ℥ viii ± Total amount ℥ xii
Drugs previously administered none.
Mucus Consid.
Heart neg.

Fig. 1. The two sides of an early anesthesia chart, especially designed for this purpose and used at an operation November 30, 1894, by Dr. E. A. Codman.

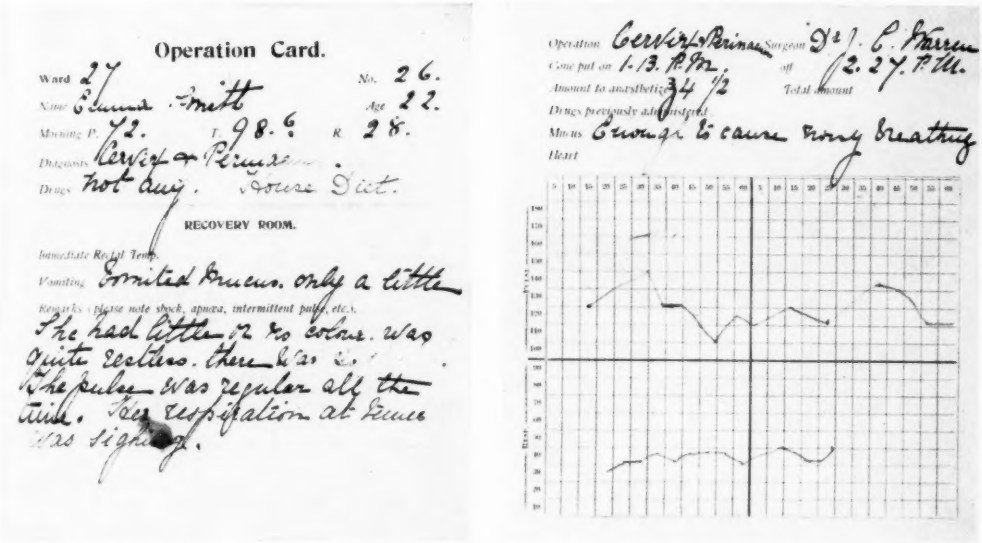

Operation Card.
Ward 27 No. 26.
Name Edmund Smith Age 22.
Morning P. 72. T. 98.6 R. 28.
Diagnosis Cervical Abscess.
Drugs not any. House Diet.
RECOVERY ROOM.
Immediate Rectal Temp.
Vomiting Vomited mucus only a little
Remarks (please note shock, apnea, intermittent pulse, etc.).
He had little if no color. Was quite restless. There was
The pulse was regular all the time. The respiration at times was sighing.
Operation Cervical Abscess Surgeon Dr. J. C. Warren
Time put on 1.13. P.M. off 2.27. P.M.
Amount to anesthetic 34 1/2 Total Amount
Drugs previously administered
Mucus Enough to cause noisy breathing
Heart

Fig. 2. The two sides of an anesthesia chart used by Dr. E. A. Codman at an operation December 17, 1894.

the unofficial one, we gave the anæsthesia, as is the custom I believe now, twenty-five years later.

"I hesitate to recall what an awful business it was and how many fatalities there were.

"My first giving of an anæsthetic was when, a third-year student, I was called down from the seats and sent in a little side room with a patient and an orderly and told to put the patient to sleep, for Dr. ——— was to operate for the class. I knew nothing about the patient whatsoever, merely that a nurse came in and gave the patient a hypodermic injection. I proceeded as best I could under the orderly's directions, and in view of the repeated urgent calls for the patient from the amphitheatre it seemed to me an interminable time for the old man, who kept gagging, to go to sleep. We finally wheeled him in. I can vividly recall, even now, just how he looked and the feel of his bedraggled whiskers.[1] The operation was started and at this juncture there was a sudden great gush of fluid from the patient's mouth, most of which was inhaled, and he died.

"I stood aside, burning with chagrin and remorse. No one paid the slightest attention to me, though I supposed that I had killed the patient. The operation was completed in spite of the episode, as a demonstration to the class. I slunk out of the hospital, walked the streets of North Boston the rest of the afternoon, and in the evening went to the surgeon's house to ask if there was any possible way I could atone for the calamity to the man's family before I left the Medical School and went into some other business.

"To my perfect amazement I was told it was nothing at all, that I had nothing to do with the man's death, that he had a strangulated hernia and had been vomiting all night anyway, and that sort of thing happened frequently and I had better forget about it and go on with the Medical School. I went on with the Medical School but I have never forgotten about it.

"Now, to come back to these ether charts. Codman and I resolved that we would improve our technique of giving ether, which in those days in the large majority of cases meant crowding the patient to the second stage of anæsthesia as quickly as possible, and for the most part we used old sea sponges.

"In order to make a game of the task before us we made a wager of a dinner as to who could learn to give the best anæsthesia. We determined to let the test of satisfactory anæsthesia rest with the patient's behavior in the ward, and though I have forgotten just what was our scale of marking the cases, a perfect anæsthesia was supposed to be one in which the patient was sufficiently conscious to respond when left in the ward with the nurse and did not subsequently vomit. You

[1] Curiously enough, it has been impossible to identify this patient in the hospital records.

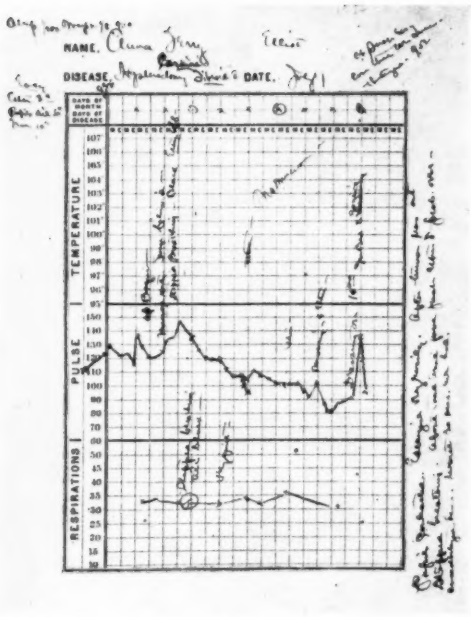


Fig. 3. The type of anesthesia chart preferred by Dr. Harvey Cushing and used by him at an operation July 17, 1895. The reverse side of the chart bears the notation in Dr. Cushing's writing. "Did not vomit. Not nauseated. Very quiet."

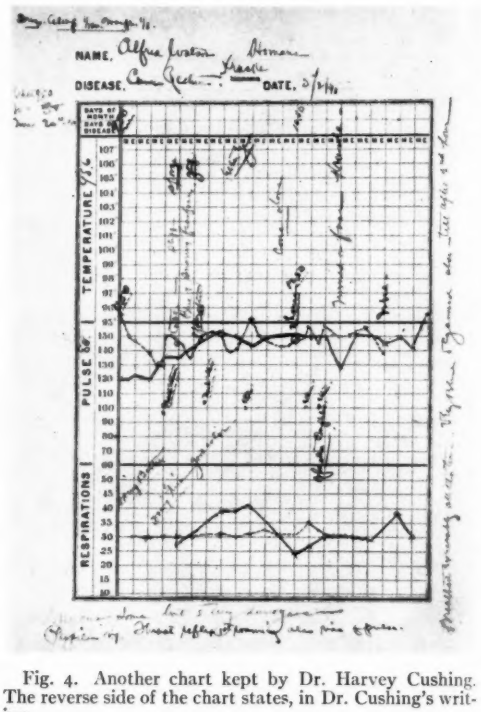


Fig. 4. Another chart kept by Dr. Harvey Cushing. The reverse side of the chart states, in Dr. Cushing's writing,
"Vomitus—Time and amount: None
"Time to come out of ether—about 2 p.m.
"Behavior—Fine
"When pulse comes down—
"At 2 p.m. asked for drink, was given cracked ice.
"Moaned continually until about 4 p.m."

will recall that in those days we had no ether recovery room in general use, except for the Saturday clinics.

"I think we both became very much more skillful in our jobs than we otherwise would have become, owing to this competition, but it was particularly due, I think, to the detailed attention which we had to put upon the patient by the careful recording of the pulse rate throughout the operation.

"Subsequently, on going abroad and getting interested in blood pressure, I discovered in use in Padua a simple recording instrument in Riva-Rocci's clinic. On returning home I came to utilize this always during the course of my neurological operations so that the procedure might be as comparable as possible to the records taken upon a kymograph during an experiment in the laboratory. A much more elaborate ether chart was thereupon prepared, on which not only pulse rate and respiration but the systolic blood pressure was recorded.

"On Dr. Councilman's instigation a paper was read here in Boston, January 19th, 1903, on the subject of The Routine Determination of Arterial Tension in Operating Room and Clinic. This was the beginning, I think, of the general use of a blood pressure apparatus in hospital wards, whether medical or surgical, for though the principle was not new the old Gärtner tonometer was most unsatisfactory because in cases of low blood pressure, the most important ones, it was utterly unreliable.

"I mention this because it is not uninteresting, in view of the universal adoption, subsequently, of instruments to measure blood pressure, to recall that the Division of Surgery appointed a committee to report on the subject. This report appeared March, 1904, *Bulletin No. 2 of the Division of Surgery*, and the final conclusion of this committee was as printed: 'The adoption of blood pressure operations in surgical patients does not at present appear to be necessary as a routine

measure.' I find I have written on my reprint the verse from Dr. Holmes' Stethoscope Song:

> 'Now such as hate new fangled toys
> Began to look extremely glum;
> They said that rattles were made for boys
> And vowed that his buzzing was all a hum.'

"I have always felt that this was one of the most interesting illustrations on record, of the reaction against the introduction of an instrument of precision into clinical use. It is precisely what happened in the case of the thermometer, the stethoscope, the X-ray, indeed of the watch itself, if one may regard Floyer's first use of the pendulum for this purpose as a watch.

"I have been moved to write all this because of the memories which have crowded in owing to a sight of these old charts, and, simple as they are, you will see that Codman and I each got up our own type of chart. I am sorry that the final score is not given, nor do I remember who had to pay for the dinner. I am quite sure, however, that I did, for Codman usually managed to beat me in most things.

"I am sending this little bundle of things to you as it is a bit of ancient history, doubtless typical of many other bits of history that concern the succession of house officers who have rejoiced in their service at the Massachusetts General Hospital. It was undoubtedly a step toward improvement in what had been a very casual administration of a dangerous drug. We do much better with ether these days, but even so there remains much to learn.

"We are still, some of us, only too careless in its use, and such studies as Dr. Cutler, and Dr. Morton made during their term of residency at the M.G.H., pointing out the frequency of post-anæsthesia pulmonary complications, are but a further step in the direction of improving our technique in its administration. I still feel that one of the most important elements in the giving of an anæsthetic is to have the anæsthetist keep during its administration a detailed chart of pulse, respiration, and blood pressure. At the time of his notable address some years ago on Ether Day, Dr. Keen, who took up this subject, intimated that too elaborate a record of this kind might take the administrator's mind from his primary job. I feel most emphatically that it keeps his mind *on* his job.

"Please put this in a corner of the Treadwell Library, where some day some young fellow may brush the dust from it and say: 'Who were these fellows anyhow, and what is this "ether" they are talking about? Do you mean that people used to be put to sleep by the inhalation of drugs in the 19th century?'"

"Very sincerely yours,
[Signed] HARVEY CUSHING

"Dr. F. A. Washburn, Supt.,
Massachusetts General Hospital
Boston, Massachusetts"

Last year letters were written to Dr. Codman and to Dr. Cushing asking permission to publish their records of 1894 and 1895 and letters of 1920. Four months before his death Dr. Cushing wrote:

" . . . I see no harm in your calling attention to the matter, should you care to do so. Still, as he [Dr. Codman] lost the wager, if my memory is correct, he may think otherwise."

Dr. Codman wrote,

"I have not seen the exhibit [the anesthesia records] in the Treadwell Library but I shall take an early opportunity to look at it, and have no doubt that I will not have any objection to its publication.

"I do not wish to take any credit for starting the charts because of my recollection the keeping of these charts was suggested by my chief, Dr. F. B. Harrington. I, of course, did the work but it was Doctor Harrington who thought that such a study would be valuable. If I recollect correctly, Doctor Cushing took up the work after I had finished my work as etherizer for I am quite sure that Doctor Cushing got his appointment about eight months later than I did, although we were in the same class in medical school."

A week later Dr. Codman wrote another letter.

"I have been to the Treadwell and seen the charts. Dr. Cushing has a way of making things interesting and dramatic even at the expense of a little inaccuracy. I recall nothing about the dinner he speaks of, or of our determination to improve the technique of anæsthesia, but we were anxious to train *ourselves* to be good etherizers!

"I took the opportunity to find the dates of our appointments as H. O.'s. As I thought, I preceded him about 8 months and am quite sure that I had already begun the use of charts at the suggestion of Dr. Harrington before H. C. appeared on the scene at all!"

In conclusion, these records of the Massachusetts General Hospital appear to be the first examples of record keeping in anesthesia. They were kept at the suggestion of Dr. F. B. Harrington, first in 1894 by Dr. E. A. Codman and later by Dr. Harvey Cushing.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

IN the second edition of his book *The Diagnosis and Treatment of Diseases of the Peripheral Arteries*[1] Dr. Samuels has covered all of the important arterial disturbances of the extremities. The book has been revised completely and lengthened by inclusion of such important conditions as peripheral arterial embolism, scalene syndrome, frostbite, ergotism, and aneurism. In the first part of the book the general symptomatology and methods of examination are discussed. This is followed by a detailed description of the etiology, signs and symptoms, and treatment of each of the conditions. Typical case reports and an extensive bibliography follow each topic. The language is simple and the book is easy to read. The subject matter is based on the author's wide experience in the peripheral circulatory clinics of New York.

As in the first edition, a great deal of stress is placed on the treatment of the occlusive vascular diseases with intravenous hypertonic salt solution and it seems that not enough space has been allotted to other therapeutic measures, including surgery, which have been found useful by other workers in the field. The reason for this, however, is probably the fact that the author has obtained such remarkably good results in the treatment of these cases by the former method. In over 500 cases of thrombo-angiitis obliterans he found it necessary to perform major amputations in only 3 cases.

A more detailed discussion of the underlying pathology and physiology would add greatly to a clearer understanding of the various conditions discussed, especially in the case of the vasomotor disturbances and arteriovenous aneurisms. The closely related disturbances of the peripheral veins and lymphatics are not discussed, but on the whole the book is a worthwhile addition to the library of those unacquainted with peripheral arterial disturbances.

SAMUEL PERLOW.

THE author's fourth edition of *Minor Surgery*[2] would be generously reviewed were I to incorporate herein the foreword by Allen Kanavel. Master of major surgery that he was, he recognized that "There is no greater field for good surgery than is presented by minor surgery." One cannot justly criticize the author's tendency to incorporate the general principles of major surgery in his volume, for the dividing line is obscure and yielding as it should be. An incompetent minor surgeon contributes many cases to the major group. Conversely, many major surgeons erroneously underestimate the value of a thorough working knowledge of the fundamentals presented so thoroughly in this volume. For the junior and senior medical year through hospital service and private or specialized practice, the author provides such a readable up-to-date review of surgical therapy, well illustrated and illuminated by many helpful hints born of his own broad experience, that one is attracted to its chapters with serious interest and wonder that such generous progress in the art and therapy of minor surgery has occurred since one has fled the field for major service. The work is rich in practical suggestions, seldom found in even our most elaborate surgical symposiums. For the beginner and the general practitioner, Christopher's *Minor Surgery* is far more valuable than any shelf of books in major surgery. Its earnest disciple will conserve life and lessen disability and build for himself the lower, but equally important rounds in the ladder of surgical success.

FRED W. BAILEY.

IN his book of over 600 pages, containing 303 illustrations, and in the preface the author[3] of *The Foot and Ankle* states that he expected to describe everything that could happen to a foot and ankle, but that he found that this would make two volumes. However, the present book seems to have left out relatively little; that is, so far as the mentioning of the various conditions is concerned, as there are 34 chapters and the table of contents covers 10 pages.

In a book of this sort devoted to a specific portion of the body it is always a question in my mind, and undoubtedly also in the mind of the author, as to how far one should go into the fields of general medicine and surgery in dealing with the various conditions encountered. For instance, here 10 pages are devoted to gout and the dietary and medicinal treatment are described in detail.

In a book on the foot and ankle one naturally expects a book in which there is a rather extensive treatise on shoes, one in which the anatomy and physiology of the foot are considered in great detail, and one which is largely devoted to static deformities of the feet and which describes in minute detail systems of exercise and various forms of supports which are used in an effort to relieve painful feet. However,

[1] THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE PERIPHERAL ARTERIES. By Saul S. Samuels, A.M., M.D. 2d ed. New York: Oxford University Press, 1940.

[2] MINOR SURGERY. By Frederick Christopher, S.B., M.D., F.A.C.S. With a foreword by Allen B. Kanavel, M.D., F.A.C.S. 4th ed. Philadelphia and London: W. B. Saunders Co., 1940.

[3] THE FOOT AND ANKLE; THEIR INJURIES, DISEASES, DEFORMITIES AND DISABILITIES. By Philip Lewin, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1940.

in this and in most other books on the subject, these subjects are not dealt with in great detail. The anatomy and physiology of the foot and ankle are covered in 17 pages and over half of this space is occupied by illustrations. The subject of shoes and the proper fitting of shoes is dealt with very briefly.

On the other hand, the author illustrates some very excellent felt supports for longitudinal and transverse arches and describes these in some detail, although he is sketchy about methods which are used by others.

Especially good are the illustrations of various types of operations for the correction of flat feet, of club feet, and of the deformities resulting from infantile paralysis. The author has taken considerable pains to obtain or reproduce the original drawings of various contributors to the literature on these subjects and is to be congratulated on reproducing some of the work of Dr. Hoke. Congenital deformities are dealt with fairly well, but not to the degree and with the detail that is usual in a standard work on orthopedic surgery. The same is true of fractures of the foot and ankle.

Deformities of the toes and hallux valgus are covered in considerable detail. Tuberculosis, syphilis, gas gangrene, pyogenic infections, and fungus infections of the foot and ankle are dealt with briefly. A number of the standard operative procedures for feet paralyzed by poliomyelitis are described and the various deformities are illustrated. Also, the nonoperative treatment of poliomyelitis, as well as the diagnosis, is taken up briefly. The section on spastic paralysis in which the Stoeffel operations are described is brief.

There is a relatively complete chapter on circulatory disturbances of the feet, including a short discussion on varicose veins and a description of the injection treatment. A 10 page chapter describes tumors and lists a large variety of neoplasms of the skin, bone, and intervening structures. The chapters on lesions of the skin and of the toe nails are especially good and practical.

There is an obvious intent to make the book encyclopedic in its scope and for this reason many subjects are of necessity dealt with very briefly. In the section on physical examination the author includes a record sheet which covers three closely packed pages, but apparently he never looks above his patients' knees. At the risk of being accused of "carrying coal to Newcastle," I suggest that the next edition include a chapter on the relation of static foot conditions to posture and body mechanics and that the patient be treated as a whole.

On the whole the book is a very valuable addition to the literature on the subject. It contains much of both theoretical and practical interest to any general surgeon or practitioner, as well as to orthopedic surgeons who treat conditions of the feet.

J. ALBERT KEY.

TO interest the practitioner in the early diagnosis and appropriate treatment of cancer is the purpose of a small book[1] recently prepared by a committee representing the Massachusetts Medical Society and the American Society for the Control of Cancer. Its distribution to the practitioners through the state is made possible by a grant of funds from the United States Public Health Service through the Massachusetts Department of Public Health and the Massachusetts division of the Woman's Field Army. The State of Massachusetts has made rather extensive provision for aiding the medical profession in the early diagnosis and adequate treatment of cancer in the indigent population and this work is an accessory to such plans. It is deserving that the work should be dedicated to two illustrious men of Massachusetts, Robert B. Greenough and George H. Bigelow, who did so much to clarify the cancer problem in Massachusetts.

The work consists of a series of 44 articles ranging from 2 to 27 pages each, prepared by men interested in the subjects they present. It is not the purpose to give a detailed description of the disease as it may affect the sundry organs of the body but is intended as a guide for the practitioner in the diagnosis of early cancer and suggests the recognized form of treatment. It is interesting to note the large amount of concrete information that can be supplied in such limited space since the majority of the articles are limited to from 4 to 6 pages. The article of 10 pages on Hodgkin's disease and allied disorders by Jackson which appeared in the *New England Journal of Medicine* in 1939 is excellent; it is brief and yet supplies all that is known today relative to the diagnosis and treatment of these conditions.

Such a work is a step in the right direction in the process of stimulating the interest of the practitioner in early cancer diagnosis and adequate treatment.

JOHN A. WOLFER.

THE third edition of *The Compleat Pediatrician; Practical, Diagnostic, Therapeutic, and Preventive Pediatrics* by Wilburt C. Davison[2] has several revisions and improvements, yet retains its original compactness and well catalogued wealth of material. The rewriting has helped to clarify many sections, and also has corrected some typographical errors. The section on growth and development is a delightful compilation of facts which are difficult to obtain anywhere else without reading several volumes. This book is a valuable storehouse of facts to have close at hand. L. MARTIN HARDY.

THE third edition of *Electrocardiography*[3] by Drs. Maher and Wosika is 334 pages long and contains 100 electrocardiograms fully interpreted, 42 schematic diagrams, and 5 roentgenograms. It

[1] CANCER; A MANUAL FOR PRACTITIONERS. The Committee on Publication: George W. Holmes, M.D., Chairman, Shields Warren, M.D., Ernest M. Daland, M.D., and Channing C. Simmons, M.D., Editor. Boston: Rumford Press, Agent, 1940.

[2] THE COMPLEAT PEDIATRICIAN; PRACTICAL, DIAGNOSTIC, THERAPEUTIC AND PREVENTIVE PEDIATRICS. 3d ed. By Wilburt C. Davison, M.A., D.Sc., M.D. Durham, N. C.: Duke University Press, 1940.

[3] ELECTROCARDIOGRAPHY. By Chauncey C. Maher, B.S., M.D., and Paul H. Wosika, M.D., M.S. 3d ed. Baltimore: The Williams & Wilkins Co., 1940.

is a clear and simple discussion of the elementary aspects of electrocardiography and includes all the more common problems that come up in this field of work. It can be read and understood by any physician as it presumes no previous knowledge of the subject. The diagrams and electrocardiograms are very clear so that the reader who might have been unfamiliar with electrocardiography would have no difficulty in understanding the analysis of the curves.

The reviewer, however, must call attention to some errors. On page 15, discussing auricular flutter, the statement is made that "accurate diagnosis is impossible without a corroborative tracing." That is hardly true with increased bedside experience. On page 36 appears the note that "the P-R interval varies in each lead, and is often longest in Lead II, where it is usually measured." The shortest P-R interval is the more accurate measurement of the conduction time. Figure XXI, on page 109, could be just as well interpreted as delayed P-R interval as nodal rhythm with the evidence at hand. A tracing during carotid sinus pressure might have differentiated the two. Bundle branch block is too often a long standing and static condition to be used as even confirmatory evidence of an acute myocardial infarction as has been done on page 175. Patients often have such curves, but the "acute episode" may be biliary colic or pulmonary infarct, etc.

Finally it would seem that the size of the book could be diminished 50 pages (and the cost thereby decreased), by putting the electrocardiograms and the interpretation on the same page.

Despite all this, the general practitioner and student will find this book very useful in familiarizing himself with a subject that is increasing in importance. SAMUEL A. LEVINE.

THE monograph on *Sulfanilamide, Sulfapyridine and Allied Compounds in Infection* by Schnitker[1] which contains 72 pages with a bibliography of 202 references is reprinted from the *Oxford Loose-Leaf Medicine*. The pharmacology, mode of action, and method of administration and dosage of sulfanilamide are followed by laboratory tests on the blood and urine. Various infections are discussed in detail in which sulfanilamide therapy is effective, doubtfully effective, and ineffective. Similar points in the use of sulfapyridine are also described. Special emphasis is given to the use of sulfapyridine in the treatment of pneumonia. Literature on sulfathiazole therapy is too recent to have been included in this volume. The book is concluded with a description of the toxic manifestations of sulfonamide compounds and their treatment.

Detailed experimental and theoretical aspects of sulfanilamide therapy have been largely omitted. In the foreword, Dr. Christian states that "the physician needs a book to turn to to find authoritative statements about the therapeutic utility of the sulfonamides, a book inclusive and comprehensive but not too long, . . ." Dr. Schnitker has been highly successful in filling this need. HOWARD L. ALT.

[1] SULFANILAMIDE, SULFAPYRIDINE AND ALLIED COMPOUNDS IN INFECTION. By Maurice A. Schnitker, M.D. Edited by Henry A. Christian, A.M., M.D., LL.D., Sc.D.(Hon.), F.A.C.P., Hon.F.R.C.P. (Can.). (Reprinted from Oxford Loose-Leaf Medicine.) New York, London, Toronto: Oxford University Press, 1940.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

PATHOLOGICAL CONFERENCES HELD AT THE COOK COUNTY HOSPITAL. By Dr. R. H. Jaffé. Edited by Chester C. Guy, M.D. Chicago: Cook County Hospital Internes' Alumni Association, 1940.

CLINICAL UROLOGY. By Oswald Swinney Lowsley, A.B., M.D., F.A.C.S., and Thomas Joseph Kirwin, M.A., M.S., M.D., F.A.C.S. Vols. 1, 2. Baltimore: The Williams & Wilkins Co., 1940.

PHYSIOLOGY OF THE FETUS; ORIGIN AND EXTENT OF FUNCTION IN PRENATAL LIFE. By William Frederick Windle. Philadelphia and London: W. B. Saunders Co., 1940.

THE DOCTOR AND HIS PATIENTS; THE AMERICAN DOMESTIC SCENE AS VIEWED BY THE FAMILY DOCTOR. By Arthur E. Hertzler, M.D. New York and London: Harper & Brothers Publishers, 1940.

BONE GRAFT SURGERY IN DISEASE, INJURY AND DEFORMITY. By Fred H. Albee, M.D., LL.D., Sc.D., F.A.C.S., F.I.C.S. Assisted by Alexander Kushner, M.D., B.Sc. New York and London: D. Appleton-Century Co., 1940.

OBSTETRICS IN GENERAL PRACTICE. By J. P. Greenhill, B.S., M.D., F.A.C.S. Chicago: The Year Book Publishers, Inc., 1940.

HOLT'S DISEASES OF INFANCY AND CHILDHOOD; A TEXTBOOK FOR THE USE OF STUDENTS AND PRACTITIONERS. By the late L. Emmett Holt, M.D., and John Howland, M.D. Revised by L. Emmett Holt, Jr., M.D. and Rustin McIntosh, M.D. 11th ed. New York and London: D. Appleton-Century Co., 1940.

GEORGES CUVIER (1769–1832). Founder of science of comparative anatomy; advanced from provincial young man to aristocratic baron and peer of France; director of higher educational institutions under Napoleon; adhered to theory of spontaneous origin of life.

"Young man, go dissect an insect. If you still believe your observations are discoveries, I will believe you."

Georges Cuvier

1769-1832

UNIV. OF MICH.